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SPECIATION AND DISPERSAL OF THE SOUTHERN BOG LEMMING, *SYNAPTOMYS COOPERI* (BAIRD)

BY RALPH M. WETZEL

The southern bog lemming *Synaptomys cooperi* (Baird) of the subgenus *Synaptomys* Baird and the northern bog lemming *S. borealis* (Richardson) of the subgenus *Mictomys* True are the only Recent species of the genus *Synaptomys*. Both are microtine-like in external appearance and tunneling habit and are assigned to the lemming group (Tribe Lemmini Simpson) of microtine rodents (Subfamily Microtinae Miller).

S. cooperi may be distinguished from *S. borealis* by the presence of closed enamel triangles on the lingual side of the cheek teeth, generally larger skull and body proportions, and in many cases by the bright chestnut pelage of some forms of *S. cooperi*. Where the ranges of the two species overlap in southern Canada, northern New England and northern Minnesota, the species have not been distinguished on the basis of habits and habitat.

The fossil history of the genus is incomplete. A late Pliocene bog lemming, *Synaptomys vetus* Wilson, of southern Idaho was regarded as intermediate between the two subgenera but more closely resembling *Mictomys* (Wilson, 1933). Hibbard (1941) assigned remains of *Synaptomys* in the Borchers Fauna, the oldest interglacial fauna of Kansas, to *vetus*. Other remains of *Synaptomys* in Meade County, Kansas, may indicate a faunal succession, not necessarily phylogenetic, from the subgenus *Mictomys* to the subgenus *Synaptomys*. The succession of species of *Synaptomys* in that area, ranked from oldest deposit to Recent, are: *S. vetus*, *S. borealis*, *S. bunkeri* Hibbard, 1939, and *S. cooperi paludis* Hibbard and Rinker, 1942. The remaining described fossil forms are from Pleistocene cave deposits and have all been assigned to the subgenus *Synaptomys*. These are *S. cooperi annexus* Peterson, 1926, of Frankstown Cave, Blair County, Pennsylvania, and *S. australis* Simpson, 1928, from a cave in Citrus County, Florida.

The genus *Synaptomys* was last revised by Howell in 1927. He examined 319 specimens of the subgenus *Synaptomys*. Following many of the conclusions of earlier studies (Merriam, 1896; Rhoads and Young, 1897), he recognized the following subspecies of *S. cooperi: stonei*, *gossii*, *cooperi*, and *helaletes*. *S. c. stonei* Rhoads ranged in the Appalachians, along the eastern seaboard, and the eastern

middle west; *S. c. gossii* (Coues) adjoined this subspecies on the west from Illinois to Arkansas and Kansas; *S. c. cooperi* Baird occupied the northern portions of the species range and adjoined *stonei* on the south; and *S. c. helaletes* Merriam occurred as an isolated race in the coastal swamps of Virginia and northern North Carolina. Since then, there has been no review of the species *Synaptomys cooperi* although some subspecies have been described. Hibbard and Rinker (1942) described a relic race, *S. c. paludis*, from Meade County, Kansas. Bole and Moulthrop (1942) described a midwestern race, *S. c. saturatus*, generally reallocating to it the eastern range of *gossii* and the central midwestern range of *stonei*. Fichter and Hansen (1947) applied the name of *gossii* to specimens from Iowa which Bole and Moulthrop had not examined. Hall and Kelson (1952) further defined certain peripheral portions of the range of *saturatus* as well as that of *gossii*. Hall and Cockrum (1953) summarized these data. They assigned to *saturatus* all populations in Illinois, middle and southern Wisconsin, southwestern Michigan, Indiana, western Ohio, eastern Missouri, and Arkansas. Otherwise, the conclusions of Howell, as modified by Bole and Moulthrop, were essentially retained.

This present study of Recent members of the subgenus *Synaptomys* has yielded some indications of intrageneric as well as intraspecific relationships and dispersal. It has involved the examination and measurement of 686 specimens from 34 collections in the United States and Canada. The study was initiated at the University of Illinois in 1947. Dr. D. F. Hoffmeister of the Museum of Natural History suggested many of the techniques and verified all pelage comparisons. Grateful acknowledgment is made to the institutions and persons in charge of the collections used in this study.

METHODS

Measurements of skull and body were charted on individual maps of the range of the subgenus and lines of gradation were drawn. By superimposing the lines of trend of the individual characters, a generalized picture of the morphological variations of the subgenus was obtained. This is essentially the technique used by Hall and Hoffmeister (1942) in studying *Peromyscus crinitus*.

As the numbers in each sample of this relatively rare lemming were quite variable—one point on a map representing a few specimens obviously lacking the same level of reliability as a point representing the mean of 60 specimens—the results of the mapping were rechecked statistically. The mean and the variation of the mean (= standard error) for each type of measurement were compared between adjoining populations. Thus, the populations in eastern Kansas were compared with those from Missouri and from Illinois. The end result of this treatment was a statistical expression of the species from individual population to subspecies to species. Both the mapping and the statistical treatments yielded compatible results.

Skull measurements were made with dial calipers to one-tenth of a millimeter. From repeated measurements of the same structure, it is believed that the error of measurement was within the range of $\pm .025$ mm. The skull measurements were selected to include those eight used by Howell (1927) as well as five additional measurements:

Length of maxillary tooth row.—Distance between the anterior and posterior margins of the alveoli of the first and last upper cheek tooth, respectively, on one side of the skull, *i.e.*, alveolar length.

Width of upper incisors.—Distance across the base of the upper incisors at the level of the lateral margins of their alveoli.

Condylobasilar length.—Distance from the posterior margin of the alveolus of one upper incisor to the posterior border of the occipital condyle on the corresponding side of the skull.

Length of incisive foramen.—Greatest length of one incisive foramen as measured on the ventral (palatal) surface of the maxillary and premaxillary bones. Only one foramen (the left) was utilized due to bilateral variation.

Nasal length.—Distance from the most anterior projection of the nasals, cleared of cartilage, to the most posterior projection of the naso-frontal suture.

Nasal width.—The greatest breadth across the nasals at right angles to the internasal suture.

Rostral length.—Distance from the most anterior projection of the zygomatic processes of the maxillae to the anterior tip of the nasals.

Rostral width.—The greatest breadth across the anterior-medial borders of the interorbital (anteorbital) foramina.

Interorbital width.—Distance across the greatest constriction between the orbits, i.e., the minimal separation of the lateral surfaces of the orbital processes of the frontal bones.

Width of supraorbital crests.—The smallest distance, if any, between the two supraorbital crests.

Zygomatic width.—The greatest distance across the zygomatic arches, at right angles to the long axis of the skull.

Lambdoidal width.—The greatest width of the posterior part of the skull, at the region of the lambdoidal ridges (superior nuchal lines) as extended ventrally to the mastoid processes. In some instances this maximum cranial-width occurred on the lateral arc of these ridges and in other skulls across the mastoid processes. Hence, the term lambdoidal-mastoidal width is equally applicable.

Height of skull.—The greatest distance between a plane taken from the ventral surface of one tympanic bulla and the crown of the last cheek tooth on that side of the skull and a plane dorsal and parallel to this that touches the dorsal-most extension of the roof of the skull.

Only those specimens assigned to an adult age group were compared by mapping and statistical methods. The following criteria were used in assigning specimens to the category of adult: (a) the processes and angles of the skull well developed and distinct (see Hinton, 1926, for a lucid exposition of maturation of a microtine skull); (b) interorbital width proportionately narrow; (c) supraorbital crests present and either fused or not widely separated. The latter criterion, also used by Howell, provided a rapid method for aging the skulls. The maximum width between apices of the crests was established conservatively for the adult group at 2.0 mm. for the larger races, such as *S. c. gossii* and *paludis*, and 1.5 mm. for the smaller *S. c. cooperi*. From collectors' notations on the labels such as "suckling", "pregnant", or testes measurements, it was found that the adult age group based on these skull characters did not include all sexually mature animals. Specimens with measurements and skull features distinguishable from adults, yet indicated as sexually active, were grouped as young adults. This conservative treatment of the adult category reduced the age spread within the group at the young side, eliminating those individuals breeding for the first time.

Sexual differences of adults were measured in certain large samples from one area. As the mean of any of the measurements for one sex was found to fall within one sigma on either side of the mean of the respective measurement for the other sex, the measurements of the two sexes were averaged together.

The following symbols are utilized to indicate collections. Where possible, the persons who made the specimens available are also indicated.

AMNH—American Museum of Natural History, New York. H. E. Anthony, G. G. Goodwin, and H. M. Van Dusen.

BS—Biological Survey Collection, Fish and Wildlife Service, Washington, D. C. S. P. Young, H. H. T. Jackson, and V. S. Schantz.

CAS—Chicago Academy of Sciences, Chicago. H. K. Gloyd.

Cinc—Cincinnati Museum of Natural History, Cincinnati. W. W. Goodpaster.
ClM—Cleveland Museum of Natural History, Cleveland. B. P. Bole.
CM—Carnegie Museum, Pittsburg. J. K. Doutt.
CNHM—Chicago Natural History Museum, Chicago. C. C. Sanborn.
Conn—Department of Zoology and Entomology, University of Connecticut, Storrs.
CU—Cornell University Museum, Ithaca. W. J. Hamilton and W. R. Eadie.
Ill—University of Illinois Museum of Natural History, Urbana. D. F. Hoffmeister.
INHS—Illinois State Natural History Survey, Urbana. C. O. Mohr and H. H. Ross.
KU—Museum of Natural History, University of Kansas, Lawrence. E. R. Hall.
LL—Collection of Leonard Llewellyn, Patuxent Wildlife Refuge, Laurel, Maryland.
MCZ—Museum of Comparative Zoology, Harvard College, Cambridge. C. P. Lyman.
Mich—Museum of Zoology, University of Michigan, Ann Arbor. W. H. Burt.
MinE—Minnesota Museum of Economic Zoology, University of Minnesota, Minneapolis.
Minn—Minnesota Museum of Natural History, University of Minnesota, Minneapolis. W. J. Breckenridge.
Mo—Zoology Department, University of Missouri, Columbia. W. H. Elder.
MSC—Morehead State College, Morehead, Kentucky.
ND—Department of Zoology, University of Notre Dame, Notre Dame.
NEB—Zoology Department, University of Nebraska, Lincoln.
NH—Collection of C. F. Jackson, Zoology Department, University of New Hampshire, Durham.
NM—U. S. National Museum, Washington, D. C. D. H. Johnson.
NMC—National Museum of Canada, Ottawa. A. W. Cameron.
NY—New York State Museum, Albany. R. S. Palmer.
Phil—Academy of Natural Sciences of Philadelphia, Philadelphia. H. R. Roberts.
PRR—Patuxent Research Refuge, U. S. Fish and Wildlife Service, Laurel, Maryland. W. H. Stickel.
PU—Museum of Zoology, Purdue University, Lafayette. C. M. Kirkpatrick.
RF—Roosevelt Wildlife Forest Experiment Station, Syracuse. R. T. King and W. A. Dence.
ROM—Royal Ontario Museum, Toronto. R. L. Peterson.
RSP—Collection of R. S. Palmer, New York State Museum, Albany.
SI—Southern Illinois University, Carbondale.
TAS—Collection of T. A. Stombaugh, Southwest Missouri State College, Springfield.

RESULTS AND DISCUSSION

Mapping and statistical treatment of the data revealed three distinct groups within *Synaptomys cooperi*. These are shown by the map, Fig. 1. One group, *S. c. cooperi*, occupies the northern part of the range of the species and is adjoined on its southern boundaries by the other two. The second group, *S. c. gossii*, a prairie form, occurs in localized and relatively undisturbed pockets from eastern Kansas, Nebraska, Iowa, and southern Minnesota, to Illinois. The third group, *S. c. stonei*, is a typical member of the southern Appalachian dispersal center first discussed by Adams (1902) and occupies the south and middle eastern part of the range of the species.

The remaining subspecies are considered as parts of one of these three primary groups. *S. c. helaletes* is an eastern coastal swamp remnant of the *stonei* group, apparently now isolated in the Dismal Swamp of Virginia and North Carolina. Although the nearest populations of *stonei* are reported in Worcester County (Poole, 1943) and Prince Georges County (Howell, 1927) of coastal Maryland, additional collecting in the interlying coastal bogs could well yield *Synaptomys*. On the present basis of discontinuity and the small sample of *helaletes* examined, synonymizing the subspecies with *stonei* is not justified.

S. c. paludis is a large, isolated remnant of the Wisconsin glacial and postglacial prairie *Synaptomys*. On the basis of generally larger dimensions of Pleistocene *S. cooperi* and the distinct isolation of this form, *paludis* is probably a relic of the former extensive south-

western range of the subgenus. Cushing (1945) found mandibles of *S. cooperi* subsp.? on the surface layer of a cave in Nuevo Leon, Mexico. The skin, without skull, of *Synaptomys* from Cherry County, Nebraska, reported by Fichter and Hansen (1947) and examined in this study, is another example of an isolated remnant of a former larger range. The colony in Meade County, Kansas, is here considered a very conservative descendant of the stock ancestral to *gossii*, and is included within the *gossii* group.

The form *S. c. saturatus* Bole and Moulthrop is not a recognizable subspecies according to data assembled. The rich chestnut or "saturate" color of *saturatus* is found to occur in varying proportions in other subspecies of *S. cooperi*. All measurements of the skull indicate, statistically and by mapped gradients, two distinct forms within the boundaries assigned to *saturatus*. Attention is called to the distinct separation of *Synaptomys* in Illinois from those in Indiana by more than two standard errors of the mean in the cases of all measurements shown in Figs. 2–5. When mapped as lines of gradation the separation of midwestern *Synaptomys* into two units is even more striking. A composite of these lines of gradation is shown on the map of the species, Fig. 1. The diagnostic features of the skull of *saturatus*, given by Bole and Moulthrop (1942) as " . . . a very long, narrow skull . . ." and "The skull is the length of . . . *gossii* (Coues) but is of the general proportions of that of *S. c. stonei*" were not applicable because of the heterogeneous groups involved. Ratios such as nasal width to nasal length and lambdoidal width to condylobasilar length did not reveal any significant unit within *saturatus*. Specimens of *saturatus* in Illinois, southwestern Wisconsin, Iowa, southern Minnesota, and Missouri were not significantly different from

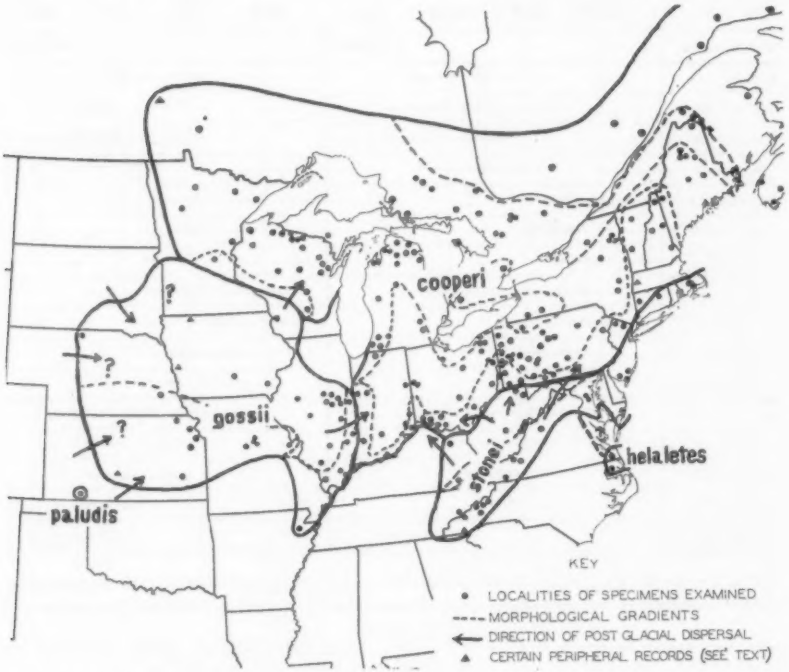

FIG. 1.—Dispersal and subspeciation of the southern bog lemming, *Synaptomys cooperi* (Baird).

specimens of *gossii* from Kansas. The eastern segment of *saturatus*, from Indiana, Ohio, and southern Michigan, was comparable to *S. c. cooperi*. From these data, therefore, *saturatus* is determined to be an artificial unit embracing a western and an eastern group, each of which is more similar to groups to their west and east, respectively, than they are to each other. Bole and Moulthrop (*loc. cit.*) had only a small number of specimens for an extremely critical area of gradation and were led to believe that these were subspecifically distinct. In Illinois, for example, specimens of *S. c. gossii* are somewhat smaller than those from eastern Kansas. Likewise the specimens of *S. c. cooperi* from Indiana, Michigan and Ohio are somewhat larger than those from Quebec and the maritime provinces. When these prairie peninsula populations of *Synaptomys cooperi* are thus considered without reference to magnitude of variation, they could conceivably appear as a homogeneous form.

Interpretation of the dispersal of *Synaptomys* is made upon two assumptions: (1) gradients in size in a more or less continuous grouping of animals parallel dispersal routes; and (2) the direction of dispersal of this particular form, as shown by these gradients, has been from the larger to the smaller. The first assumption has general application to all animals while the second assumption can be applied only where justified by evidence. The evidence is that the fossil members of this subgenus are larger generally than the Recent forms; that conservative and relic pockets of the subgenus on the western side of its shrinking range are larger in size than the populations to the east; and that the forms in the parts

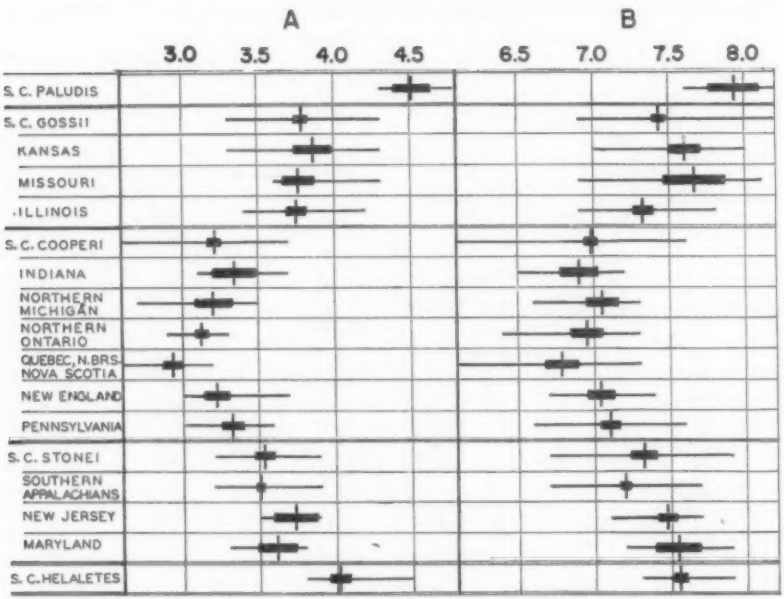

FIG. 2.—A—Width of upper incisors, mm. B—Length of upper incisors, mm. *Explanation.* Means indicated by vertical lines, range of measurements indicated by smaller, horizontal lines; two standard errors (S.E. = $\sqrt{\frac{\Sigma fd^2}{N(N-1)}}$ on either side of means indicated by horizontal bars.

of the range that have been most recently made available for population—midwestern and eastern areas of Wisconsin glaciation—are the smallest members of the subgenus.

From these assumptions the speciation of *Synaptomys* is interpreted as follows. The subgenus *Synaptomys* was divided and stabilized at the time of a recent glacial advance, such as the Wisconsin. The division in the middle part of its range would have well been accomplished by the large Mississippi-Ohio glacial drainage, with the ancestral *gossii* group on the west and the ancestral *stonei* group on the east. With the retreat of the glacial sheet the more mobile segments of these populations on the fringe of the glacier dispersed into the north middlewest, New England and Canada. There the southern bog lemming met with the eastward and southward invasion of the northern bog lemming, *S. borealis*, from the Rocky Mountain chain.

Although the latter part of this assumption concerning the subgenus *Mictomys* is conjectural, certainly the dispersal of *stonei* to the north and westward and the dispersal of *gossii* to the north and eastward are points well justified from the data. The morphological gradients from typical *stonei* to *S. c. cooperi* of northern New England to *cooperi* of Quebec and maritime provinces are evident in all measurements (Table 1, Figs. 2–5). In like fashion the gradients down the Ohio drainage from the Appalachians point up the westward dispersal of *stonei*. Such a postglacial drift from the southwestern Appalachian area is typical of the general biota of the area, as has been remarked by Adams (1902), Braun (1947), and Hooper (1949). *S. c. stonei* on the Atlantic coastal plains of Maryland, New Jersey, southern Connecticut and coastal Massachusetts can perhaps be resolved by the assumption of established *Synaptomys* in these and in now inundated coastal areas during the time of the last glacial advance. The eastward dispersal of *gossii* is likewise indicated by morphological gradients (Table 1, Figs. 2–5).

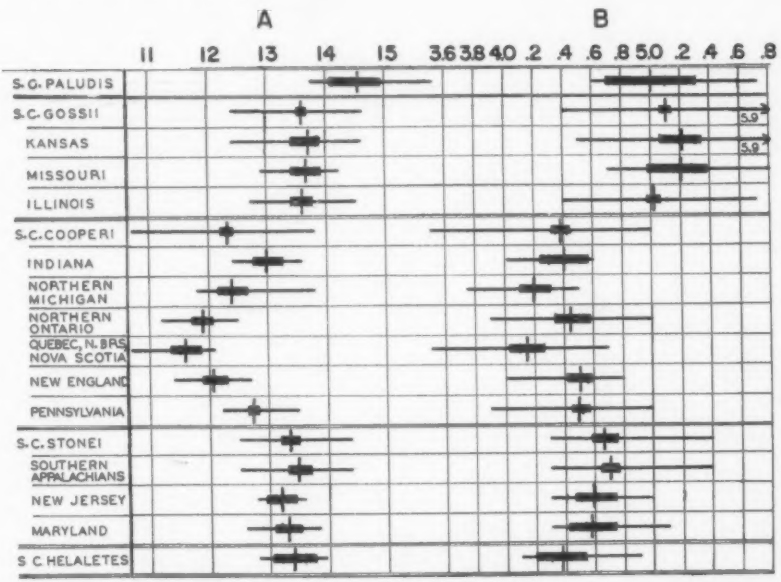

FIG. 3.—A—Lambdoidal width, mm. B—Length of incisive foramen, mm. *Explanation.* See Fig. 2.

Descriptions of the Recent subspecies of *Synaptomys cooperi* follow:

Synaptomys cooperi cooperi (Baird)

Myodes (*Synaptomys*) *cooperii* Baird, Rept. Expl. and Surveys, 8 (1): xliv, 1857 and Rept. North Amer. Mammals, p. xxx, 1857.

Synaptomys (*S. cooperi*) Baird, *op. cit.*, p. 558, 1857.

Synaptomys cooperi, Coues, Proc. Acad. Nat. Sci. Phila., p. 194, 1874.

Synaptomys fatuus Bangs, Proc. Biol. Soc. Wash., 10: 47, 1896 (type loc.: Lake Edwards, Quebec).

Synaptomys cooperi Merriam, Proc. Biol. Soc. Wash., 10: 58, 1896.

Synaptomys fatuus, Merriam, *op. cit.*, p. 58, 1896.

Synaptomys cooperi cooperi, Rhoads and Young, Proc. Acad. Nat. Sci. Phila., p. 305, 1897.

Synaptomys cooperi fatuus, Rhoads and Young, *op. cit.*, p. 306, 1897.

Synaptomys cooperi cooperi, Howell, North Amer. Fauna No. 50: 12, 1927.

Synaptomys cooperi saturatus Bole and Moulthrop, Sci. Publ. Cleveland Mus. Nat. Hist., 5: 149, 1942, part (type loc.: Bloomington, Ill.).

Type Locality.—Not designated by Baird (1857) although he speculates that " . . . the animal (i.e. type specimen) is . . . . probably from the New England States . . ." Rhoads and Young (1897) defined the type locality of *Synaptomys cooperi* as ". . . lying within a radius of Hoboken, New Jersey, either in northern New Jersey, southern New York, or eastern Connecticut." Jackson, Carroll County, New Hampshire, was assigned by Bole and Moulthrop (1942) as type locality, following Baird's lead rather than Rhoads and Young's more logical selection of an area having as its center William Cooper's home.

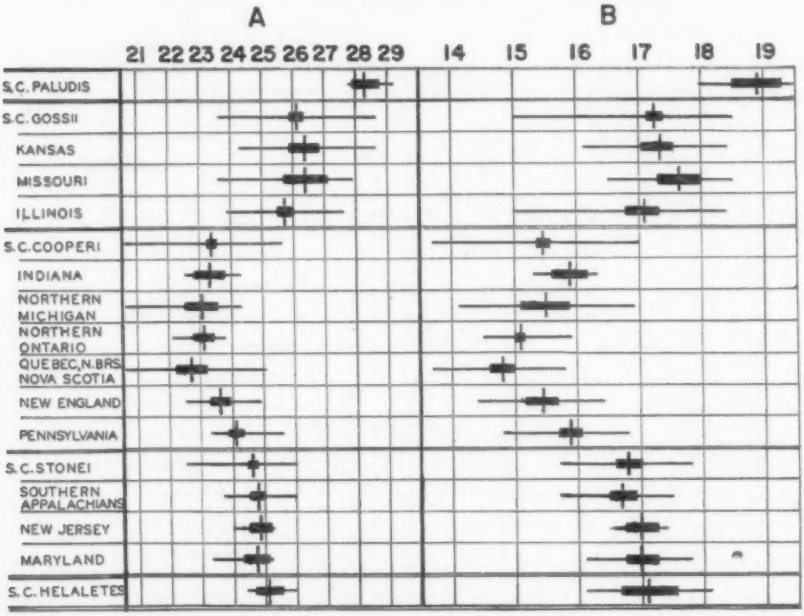

FIG. 4.—A—Condylobasilar length, mm. B—Zygomatic width, mm. *Explanation*. See Fig. 2.

Range.—Southeastern corner of Manitoba (Sandilands Forest Preserve) east across southern Ontario and Quebec to the northern shore of the Gulf of St. Lawrence (Saguenay County), Cape Briton Isle, Nova Scotia, New Brunswick and south into central Minnesota, all of Wisconsin except the driftless area, all of Michigan, Indiana, Ohio, Pennsylvania, northwestern corner of New Jersey (Passaic and Sussex counties), northwestern corner of Connecticut (Litchfield County), western Massachusetts, and all of northern New England. The record in western Massachusetts, Berkshire County, (Trippensee, MS, 1952) was obtained by a student and the specimen was not available for examination in this study.

Diagnosis.—Body and skull comparatively small (see Table 1 and Figs. 2–5). The dimensions that are most consistently characteristic and usable for subspecific determination include the following, based upon measurements of 195 adult *S. c. cooperi* from over all its range: width of upper incisors narrow, with a mean of 3.2 ± .02 mm. (range 2.6–3.7 mm.); nasal width usually larger than width of upper incisors, with a mean of 3.3 ± .02 mm. (range 2.8–4.0 mm.); condylobasilar length small, with a mean of 23.4 ± .06 mm. (range 20.6–.256 mm.); zygomatic width disproportionately narrow, with a mean of 15.5 ± .05 mm. (range 13.7–17.0 mm.); height of skull relatively low, with a mean of 9.3 ± .04 mm. (range 8.3–10.8 mm.). A distinct increase in size of specimens in the southern periphery of the range is illustrated by the localities from which came the specimens having the extreme upper range in the foregoing figures: Sherburne Co., Minnesota (maximum width of upper incisors); Tippecanoe Co., Indiana (maximum widths of upper incisors and nasals); Portage Co., Ohio (maximum zygomatic width); Fulton Co., Pennsylvania (maximum condylobasilar length and height of skull). The foregoing minimum measurements occurred in specimens from the northeastern portion of the range.

An impression of slenderness of the skull was received from specimens examined. The width of the skull at the zygomatic arch as compared to condylobasilar length is relatively narrow, falling at or close to an index of .65. The skulls are also low crowned, with a height

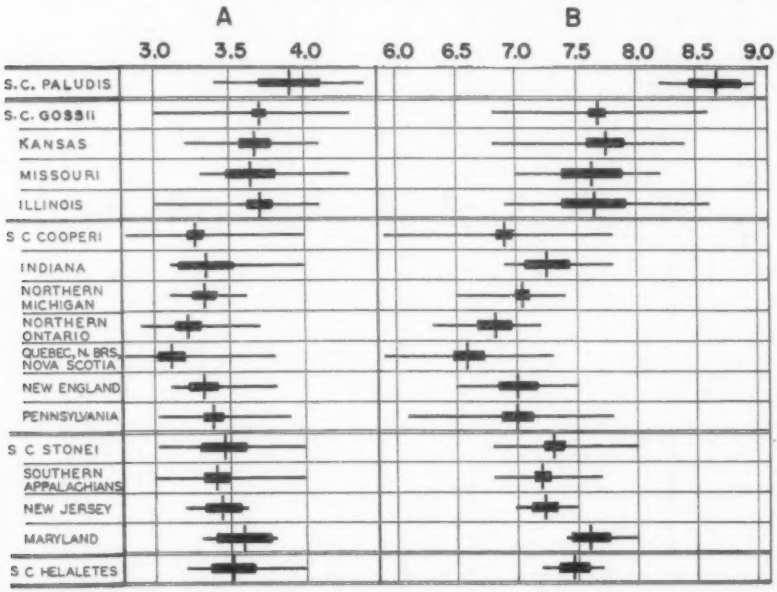

FIG. 5.—A—Nasal width, mm. B—Nasal length, mm. *Explanation.* See Fig. 2.

TABLE 1.—*Summary of certain body and cranial measurements. The first figure is the mean, the second is the standard deviation of the mean or standard error* $\left(SE = \sqrt{\frac{\Sigma fd^2}{N(N-1)}}\right)$

S. cooperi subspecies	No.	Total length of body	Length of tail	Length of hind foot	Length of maxillary tooth row	Width of upper incisors	Condylo-basilar length	Length of incisive foramen	Nasal length	Nasal width	Rostral length	Rostral width	Zygomatic width	Lambdoidal width	Height of skull
paludis	8	144.4 2.2	21.6 .59	21.6 .18	7.9 .08	4.5 .06	28.3 .18	5.0 .15	8.7 .10	3.9 .12	6.7 .12	6.7 .07	18.9 .19	14.5 .22	12.0 .14
gossii	98	128.8 .71	19.2 .26	19.5 .10	7.4 .02	3.8 .02	26.1 .09	5.1 .02	7.7 .03	3.7 .02	6.2 .02	6.1 .02	17.2 .05	13.6 .04	11.1 .05
Eastern Kansas	24	133.0 1.8	21.5 .62	20.3 .13	7.6 .05	3.9 .06	26.4 .24	5.2 .07	7.7 .07	3.7 .05	6.2 .02	6.1 .10	17.3 .13	13.7 .12	11.2 .13
Missouri	12	125.1 2.7	18.8 .68	19.8 .27	7.7 .10	3.8 .05	26.4 .36	5.2 .10	7.6 .12	3.6 .08	6.3 .09	6.2 .07	17.7 .17	13.7 .12	11.0 .19
Illinois	57	128.6 1.0	18.3 .40	19.0 .27	7.3 .03	3.8 .03	25.8 .12	5.0 .04	7.7 .13	3.7 .04	6.2 .05	6.1 .04	17.1 .17	13.6 .08	11.1 .10
cooperi	195	118.7 .26	18.9 .20	18.6 .10	7.0 .02	3.2 .02	23.4 .06	4.4 .03	6.9 .03	3.3 .02	6.1 .03	5.3 .02	15.5 .05	12.3 .05	9.3 .04
Indiana	10	112.5 4.3	16.0 .92	17.3 .45	6.9 .06	3.3 .07	23.3 .27	4.4 .08	7.3 .09	3.3 .09	6.2 .16	5.5 .08	15.9 .14	13.0 .13	9.9 .12
Ohio	8	118.3 1.8	18.4 .65	18.3 .13	7.0 .04	3.3 .07	23.9 .23	4.5 .07	7.1 .07	3.2 .06	6.2 .08	5.4 .12	15.9 .15	13.2 .21	9.7 .16
Northern Wisconsin	14	119.8 1.5	18.4 1.2	18.7 .18	6.7 .05	3.2 .06	22.6 .16	4.3 .05	6.7 .08	3.2 .06	5.9 .08	5.2 .05	15.4 .33	12.1 .11	9.3 .12
Northern Michigan	16	117.5 1.6	18.2 .86	18.4 .18	7.1 .05	3.2 .06	23.0 .26	4.2 .05	7.0 .06	3.3 .04	6.1 .10	5.4 .07	15.5 .19	12.4 .13	9.5 .11

Upper Ontario	22	115.0 1.2	18.6 .48	18.0 .52	7.0 .05	3.1 .02	23.1 .15	4.5 .06	6.8 .07	3.2 .04	5.9 .06	5.0 .03	15.1 .03	11.9 .08	8.8 .04
Quebec and the maritime Provinces	24	114.4 1.3	18.1 .70	18.0 .11	6.8 .05	2.9 .03	22.7 .26	4.1 .06	6.6 .06	3.1 .04	5.9 .07	4.9 .03	14.8 .09	11.6 .12	8.8 .09
Northern New England	21	117.6 1.7	19.2 .32	20.4 .24	7.0 .04	3.2 .04	23.6 .17	4.5 .04	7.0 .08	3.3 .05	6.1 .07	5.2 .07	15.4 .14	12.1 .10	9.1 .08
Western and central Pennsylvania	40	123.2 .65	20.1 .47	19.0 .14	7.1 .03	3.3 .03	24.1 .09	4.5 .04	7.0 .06	3.4 .03	6.1 .05	5.5 .03	15.9 .08	12.8 .02	9.5 .08
stonei	46	126.6 .91	20.6 .51	19.7 .12	7.3 .04	3.5 .03	24.7 .12	4.7 .04	7.3 .04	3.5 .07	6.5 .06	5.8 .04	16.8 .10	13.3 .07	10.1 .06
Southern Appalachians	26	127.8 1.2	21.3 .63	19.7 .15	7.2 .01	3.5 .01	24.8 .08	4.7 .02	7.2 .03	3.4 .04	6.4 .08	5.7 .04	16.7 .11	13.5 .10	10.1 .08
New Jersey	6	125.2 2.6	20.2 .87	20.5 .18	7.5 .03	3.7 .07	24.9 .19	4.6 .12	7.2 .10	3.5 .06	6.7 .22	6.0 .05	17.0 .13	13.2 .12	10.1 .11
Maryland	9	125.6 2.2	20.4 .48	19.1 .23	7.5 .07	3.6 .06	24.7 .19	4.6 .08	7.6 .08	3.6 .09	6.6 .11	5.9 .07	17.0 .17	13.3 .11	10.2 .09
helaletes	10	125.4 1.9	20.0 .12	19.6 .08	7.6 .02	4.0 .03	25.1 .20	4.4 .08	7.5 .06	3.5 .07	6.4 .08	6.3 .07	17.1 .22	13.4 .18	10.5 .17

of skull to condylobasilar length index of .40. The comparative narrowness of the skulls at the zygoma and the low braincase statistically bear out the impression of slenderness. Other ratios such as lambdoidal width and nasal length to condylobasilar lengths do not significantly differ from ratios for other races. The upper incisors are usually narrower than the nasals, with a nasal to width of incisor ratio in the specimens examined ranging from 1.07 to equality. Interorbital and temporal ridges, although present in adults, are proportionately small. Howell's (1927: 12, 13) contention that "Interorbital and temporal ridges practically absent in characteristic specimens" must have been based upon examination of immature and young adults.

Pelage silver on venter and brown to chestnut, grizzled with light, on dorsum, as with subgenus. The variations in color are much greater within only one sample of *cooperi* for one season than between the different subspecies of *Synaptomys cooperi*. Dark chestnut forms (*saturatus* type of Bole and Moulthrop, 1942) occur in *S. c. cooperi* both within and outside the range assigned to *S. c. saturatus*.

Comparison.—*S. c. cooperi* is smaller in all dimensions of body and skull than other races. This is generally proportional except for lower crowned skull and narrower skull across the zygomatic arches as compared to length of skull, and narrowness of incisors as compared to nasal widths, as mentioned above. The ranges of all measurements overlap the ranges of measurements for the adjoining races *gossii* and *stonei*, indicating the difficulty of separation of some single specimens or small samples of *cooperi* from neighboring subspecies. However the means of the majority of measurements of the regional groups of *cooperi* were more than two standard errors of the mean smaller than the lower extremes (of also two standard errors) of the means of measurements of the neighboring races.

The dorsum is somewhat lighter than *gossii* and less grizzled than *stonei*. The venters of *cooperi* are slightly lighter silver than in other races due to the less frequent occurrence of the saturate or chestnut form.

Remarks.—S. F. Baird's first mention of this genus occurred in his "Table of Higher Groups" as *Myodes* (*Synaptomys*) (1857*a*, p. xxx; *b*, p. xvi). Following this, in his "List of Species," the trivial name appeared, also with suitable page reference, as *Myodes cooperii* Baird (n.s.) under the Subdivision (a term used by Baird in the case of the genus *Arvicola* for intrageneric grouping, but not assigned subgeneric value, see p. 514) *Synaptomys* (1857*a*, p. xliv; *b*, p. xxx). It is believed necessary to assign page priority to the preface nomenclature, which is accompanied by suitable page references, over the nomenclature in the text, "*Synaptomys* (*S. cooperi*)" (p. 558).

Intergradation of *S. c. cooperi* with *S. c. gossii* was observable in specimens from Clark and Waukara counties, Wisconsin; Sherburne County, Minnesota; and western Indiana. Intergradation with *S. c. stonei* was apparent in specimens from the Appalachian plateau areas of Ohio and other regions immediately in the Ohio River drainage: Belmont, Brown, Cleremont, and Hamilton counties in southern Ohio, and Franklin, Ripley, and Ohio counties in southern Indiana. Specimens of *S. c. cooperi* throughout Pennsylvania generally were intergrades with *stonei* and differed the most in having smaller zygomatic arches.

In Canada specimens from the region of southwestern Ontario bounded by Lakes Huron and Ontario and the Ottawa River were similar to specimens from Michigan, New York, and Pennsylvania. Clines were exhibited for these populations from southern Canada and northern United States, from larger to smaller dimensions, through the northern part of the range of the species in Ontario to the populations in Quebec and the maritime provinces. A similar cline was observable from Pennsylvania through New York and New England to Quebec and the maritime provinces. The magnitude of the cline within *S. c. cooperi* between populations in Quebec and the maritime provinces on one hand and populations to the south and west is generally as large as exists between the poorly defined subspecies *S. c. helaletes* and *S. c. stonei*.

Specimens examined.—Total, 400, as follows: **Connecticut.** *Litchfield:* Macedonia Park, 1, AMNH. **Indiana.** *Franklin:* Brookville, 6 (1 skin only), NM, 1, Cinc. *Jay:* Salamonia, 8 (3 skulls only), CNHM. *Knox:* Bicknell, 1 (alc), NM. *Lawrence:* Mitchell, 2, NM. *Ohio:*

Bascom, 4 (2 alc), NM. *Ripley:* no loc., 1, PU. *St. Joseph:* Notre Dame, 2, ND. *Tippecanoe:* Lafayette, 4, PU. *Warren:* no loc., 1, PU. **Maine.** *Aroostook:* Madawaska, 2, MCZ. *Oxford:* Twp. 5, Range 4, 5, RSP. *Penobscot:* east branch Penobscot River, 1, BS. *Piscataquis:* Twp. 7, Range 13, 17, RSP; Twp. 7, Range 11, 1, Conn; Twp. 8, Range 12, 2 (1 skull only), RSP; Sebec Lake, 1, BS. **Michigan.** *Alcona:* Harrisville, 2, Mich. *Alpena:* Ossineke, 1, Mich. *Berrien:* Warren Woods, 1, Mich. *Cass:* Cassopolis, 3, Mich. *Charlevoix:* Boyne Falls, 4, Mich; Susan Lake, 1, Mich; Young State Park, 1, Mich. *Cheboygan:* Douglas Lake, 1, Mich. *Clare:* Harrison, 1, Mich. *Crawford:* Grayling, 2, Mich. *Dickinson:* Channing, 1 (skull only), CNHM. *Kalamazoo:* Ross Twp., 1, Minn. *Leelanau:* Traverse Creek, 1, Mich. *Livingston:* George Reserve, 10, Mich. *Montmorency:* Hunt Creek Exp. Sta., 1, Mich. *Newaygo:* White Cloud, 1, Mich. *Ostego:* Pigeon River State Forest, 1, Mich. *Presque Isle:* Barnhart Lake, 1, Mich. *Van Buren:* Van Auken Lake, 1, Mich. *Washtenaw.* Ann Arbor, 5, Cinc. **Minnesota.** *Beltrami:* Waskish, 1, Minn. *Clearwater:* Itasca State Park, 2, MinE, 1 (skin only), Minn. *Lake:* Clear Lake Portage, 1, Minn. *Pine:* Grass Lake, 1 (skin only), Minn. *Sherburne:* Elk River, 3, NM. *St. Louis:* Pelican Lake bog, Orr, 1 (skin only), MinE. **New Hampshire.** *Carroll:* Intervale, 2, NH. *Coos:* Pittsburg, 1, ClM. *Grafton:* Mt. Moosiilauke, North Woodstock, 1, MCZ. *Strafford:* Durham, 9 (2 skins only), CU, 1, MCZ. **New Jersey.** *Passaic:* Greenwood Lake, 2, Phil. *Sussex:* Long Lake, 2, Phil. **New York.** *Albany:* Rensselaerville, 7 (3 skins only, 1 skull only), CU, 1, NY. *Allegany:* Alfred Center, 1 (skull from owl stomach), NM. *Cattaraugus:* Allegheny State Park, 1, CU. *Essex:* Clear Lake, 2, NY; Catlin Lake, 5, RF; Giant Mt., 1, ClM; Keene Heights, 4, MCZ. *Greene:* Catskill Mts., 1, NM. *Hamilton:* Morehouse Twp., 1, RSP. *St. Lawrence:* Wanakena, 1, BS. **Ohio.** *Adams:* Meags, 1, Cinc. *Ashland:* Loudonville, 1, Mich. *Athens:* Athens, 1, NM. *Belmont:* Powhatan Point, 1, ClM. *Brown:* Ripley, 1, ClM. *Clermont:* Owensville, 22, Cinc; Chilo, 1, ClM. *Columbiana:* Leetonia, 1, ClM; Lisbon, 1, ClM. *Fairfield:* Greenfield Twp., 2, ClM. *Geauga:* Chesterfield Coves, 2, ClM; Thompson Twp., 1, ClM. *Hamilton:* Cincinnati, 5, Cinc; Sedamsville, 1, NM; no loc., 1, ClM. *Highland:* 1, Cinc. *Lake:* Holden Arboretum, 2, ClM. *Mercer:* Coldwater, 1, ClM; Ft. Recovery, 1, ClM. *Portage:* Aurora Pond, 1, ClM; Ravenna, 2, AMNH. *Seneca:* Bettsville, 1, ClM. **Pennsylvania.** *Armstrong:* Manorville, 1, CM. *Beaver:* Beaver, 1, CM; Bealer's Run School, 1, CM; New Galilee, 1, CM; Rowtown, 2, CM. *Bedford:* Chaneysville, 2, CM; Imler, 2, CM. *Butler:* Hooker, 1, CM; Middle Lancaster, 1, CM; Mars, 2, CM; Saxonburg, 4, CM. *Cambria:* Cresson, 3 (1 skull only), CM; Krings, 5, Phil. *Cameron:* Emporium, 4, CM. *Clearfield:* McGees Mills, 2, CM. *Clinton:* Renovo, 2, CM; Round Island, 2, Phil. *Crawford:* Linesville, 1, CM. *Fayette:* Markleysburg, 2, CM. *Fulton:* Amaranth, 1, CM; McConnellsburg, 10, CM; Needmore, 1, CM; Warfordsburg, 1, CM. *Greene:* Waynesburg, 1, CM. *Huntingdon:* Orbisonia, 1, CM. *Indiana:* Cessna Run, Glen Campbell, 1, CM. *Lawrence:* Cheeseman's Run, 1, CM. *Mercer:* Mercer, 2, CM. *Monroe:* Bushkill Creek, Cresco, 1 (skin only), Phil. *Perry:* Landisburg, 1, CM. *Somerset:* Somerset, 1, CM. *Sullivan:* Lake Leigh (Lake Lehigh, Howell, 1927,?), 1, Phil; Hillsgrove, 1, CM. *Venango:* Franklin, 1, CM. *Warren:* Weldbank, 2, CM. *Washington:* Burgettstown, 2, CM. *Westmoreland:* Rector, 1, CM. **Vermont.** *Lamoille:* Mt. Mansfield, 1, BS. *Rutland:* Mendon, 5, MCZ. **West Virginia.** *Brooke:* Bethany, 1, BS. **Wisconsin.** *Ashland:* Bear Lake, Ashland, 3, CNHM. *Clark:* Withee, 1, BS. *Columbia:* Kilbourn, 2, BS. *Douglas:* Solon Springs, 1, CNHM. *Iron:* Mercer, 1, BS. *Marathon:* Rib Hill, 1, BS. *Oconto:* Kelly Lake, 2, BS; Lakewood, 1, BS. *Oneida:* Rhinelander, 1, Phil. *Shawano:* Keshena, 1 (skin only), CAS. *Vilas:* Conover, 3, CNHM; Lac Vieux Desert, 1, CNHM; Lake St. Germain, 2, BS; Sayner, 1, CNHM. *Washburn:* Long Lake, 2, BS. *Waushara:* Wild Rose, 2, BS. **Ontario.** *Algoma District:* Pancake Bay, 1, NMC; MacLeanan, 6, ROM. *Bruce:* Tobermory, 1, ROM. *Kenora:* Minaki, 1, Phil. *Lambton:* Thedford, 2, ROM. *Muskokoa District:* Camp Billie Bear, 1, ROM; Port Sidney, 1, ROM. *Nipissing District:* a) *Algonquin Park area:* Brule Lake, 3, ROM; Cache Lake, 3, ROM; Costello Lake, Sproule Twp., 1, ROM; Kathlyn Lake, Canisbay Twp., 1, ROM; Sasajewan Lake, Canisbay Twp., 2, ROM; Smoke Lake, 1, ROM; Source Lake, Peck Twp., 1, ROM; no loc., 1, NMC. b) *Lake Timagami area:* Cross Bay, 1, ROM; McLean Peninsula, 3, ROM; Portage Bay, 2, ROM; Timagami, 4, ROM; Wabikon Camp, Lake Timagami, 2, Phil. *Parry Sound District:*

Frank's Bay, 2, ROM. *Renfrew:* Golden Lake, 1, ROM. *Sudbury District:* Biscotasing, 3, ROM; Chapleau, 1, ROM; Ridout, 2, NMC; Whitefish, 1, ROM. *York:* Sheasville, 1, ROM. **New Brunswick.** *Charlotte:* St. Andrews, 2, NMC. *Gloucester:* Miramichi Rd. 15 mi. from Bathurst, 3, NMC. *Madawaska:* Edmunston, 1, NMC; St. Leonard, 2, NMC. *Victoria:* Tobique Point, 1, AMNH. **Nova Scotia.** *Digby:* Digby, 5, MCZ. *Queens:* Lake Kedgemakooge, 3, MCZ. *Shelburne:* North Barrington Passage, 2, NMC; St. Clyde, 1, NMC. *Victoria:* Cape Briton Island, Cheticamp Lake, 1, NMC. **Quebec.** *Quebec:* Lake Edwards, 5, MCZ, 1, Phil; Valcartier Military Camp, Conway Lake, 2, NMC. *Saguenay:* Godbout, 1, BS, 2 (alc), NM; Mingan, 1, NM; St. Margaret River, 7, CM. *Temiscouata:* St. Rose, 2, BS. *Wright:* Blue Sea Lake, near Messines, 2, NMC. *No county data:* Lac Aux Sables, 1, Phil. **No locality.** 1 (No. 1368), NM.

Synaptomys cooperi stonei Rhoads

Synaptomys stonei Rhoads, Amer. Nat., 27: 53, 1893.

Synaptomys cooperi, Merriam, Proc. Biol. Soc. Wash., 10: 58, 1896, part.

Synaptomys cooperi stonei, Rhoads and Young, Proc. Acad. Nat. Sci. Phila., p. 306, 1897.

Synaptomys cooperi stonei, Howell, North Amer. Fauna No. 50: 14, 1927.

Type locality.—Mays Landing, Atlantic County, New Jersey.

Range.—Southern Appalachians of eastern Kentucky and Tennessee, western North Carolina and Virginia, West Virginia, and eastern Maryland, to the Atlantic coastal plains of Maryland, New Jersey and northward to Connecticut (north to Tolland County) and coastal Massachusetts. The most southeasterly record is that of Poole (1943) in Worcester County, Maryland. The southernmost record is that of Odum (1948) in Macon County, North Carolina, less than ten miles from the Georgia state line.

Diagnosis.—Body and skull comparatively large (Table 1), as illustrated by the following selected measurements from 46 adult *S. c. stonei* from throughout its range: width of incisors, 3.5 ± .03 (range 3.2–3.9 mm.); nasal width, 3.5 ± .07 mm. (range 3.0–4.0 mm.); rostral width, 5.8 ± .04 mm. (range 5.3–6.2 mm.); condylobasilar length, 24.7 ± .12 mm. (range 22.5–26.0 mm.); zygomatic width, 16.8 ± .10 mm. (range 15.7–17.8 mm.); height of skull, 10.1 ± .06 mm. (range 9.4–10.9 mm.). The lower extremes of the measurement of the subspecies occur generally in peripheral areas of its range: Plymouth County, Massachusetts (minimum rostral width, condylobasilar length, and height of skull); Pocahontas County, West Virginia (minimum width of incisors); Preston County, West Virginia (minimum zygomatic width); Prince Georges County, Maryland (minimum nasal width); Yancy County, North Carolina (also minimum nasal width). The skulls are wide at both lambdoidal and zygomatic regions and higher crowned, in relation to length of skull. The ratios of lambdoidal width to condylobasilar length fell at or near .54 and zygomatic width to condylobasilar length at or near .68. The ratios of height of skull to condylobasilar length fell at or near .41. The nasal widths are slightly smaller or equal to widths of upper incisors, as indicated by ratios falling between .97–1.00 for the specimens examined. Other ratios such as nasal length to condylobasilar length, nasal width to length, and lambdoidal width to zygomatic width differed little from similar ratios for other races.

Comparison.—See comparison of *S. c. cooperi* with *stonei*, above. *S. c. stonei* is distinguishable from *S. c. helaletes* by characters of the skull, although no significant differences were seen in the pelage of the two forms. The skull of *stonei* is significantly smaller in condylobasilar length, length of maxillary tooth row, nasal length, rostral breadth, height of skull, and width of upper incisors. It is significantly larger in length of incisive foramen. Proportionately the skull of *stonei* differs most markedly from *helaletes* in having a nasal width that nearly equals width of incisors, rather than being proportionately smaller as in *helaletes*.

A general impression of pelage difference was obtained for *S. c. stonei*, with less dark chestnut on dorsum in *stonei* as compared to *gossii*. The greater abundance of light brown hairs gives a more grizzled appearance to the dorsum. This served to distinguish *stonei* from both *gossii* and *cooperi*. However the general considerations of greater variation in pelage

within any one population than between subspecies, discussed above with *S. c. cooperi*, are equally applicable to *stonei*.

Remarks.—Intergradation of *S. c. stonei* from a southern Appalachian center with *S. c. cooperi* to the west and north was apparent in both mapping and statistical comparisons of specimens from the Appalachians, Pennsylvania, New England, and eastern and southern Ohio. The breadth of these areas of intergradation with *cooperi* is considerable, occupying large areas of the southern range of the latter form. Morphological gradients stem from larger forms of *stonei* in the Appalachians of North Carolina, Tennessee, Kentucky, and Virginia and the eastern seaboard areas of its range through smaller *stonei* at the periphery of its range in West Virginia and eastern Massachusetts. The clinal division between *stonei* and *cooperi* is not, with individual specimens, often clear cut, as the step-like gradient continues within the range of *cooperi* on through Pennsylvania, New York, New England, southern Ontario, Ohio, Indiana, and Michigan. Due to the intergradation with *cooperi* in the latter three states, Howell (1927) was led to assign these areas to *stonei*. That this is not the case, is illustrated by the statistically different populations of *cooperi* from these areas, as compared to typical *stonei* of the southern Appalachians, shown in Fig. 3B, Length of Incisive Foramen; Fig. 4A, Condylobasilar Length; and Fig. 4B, Zygomatic Width.

The seaboard range of *S. c. stonei* has conceivably shortened, in the post glacial history of the form, and was once continuous with that of *S. c. helaletes*. It can be assumed that no subspecific differences existed at that time.

Specimens examined.—Total, 84, as follows: **Connecticut.** *Tolland:* Mansfield, 1, Conn; Storrs, 2, Conn. **Kentucky.** *Harlan:* Lynch, 1, NM. *Rowan:* Morehead, 1, MSC. **Maryland.** *Prince Georges:* Beltsville, 1, NM; Hyattsville, 7 (1 skull only), BS, 1, PRR. **Massachusetts.** *Plymouth:* Plymouth, 1, MCZ; Wareham, 4, MCZ. **New Jersey.** *Atlantic:* Mays Landing, 2, Phil, 1, BS. *Cape May:* Tuckahoe, 1, Phil. *Cumberland:* Port Norris, 3, Phil. **North Carolina.** *Buncombe:* Weaverville, 10 (4 skulls only, 1 skin only), AMNH. *Madison:* Marshall, 3, CIM. *Mitchell:* Magnetic City, 1, BS; Roan Mt., 7, BS, 6 (4 skin only), Phil. *Swain:* Great Smoky Mountains National Park, Indian Gap, 1, BS, Silers Bald, 2, Conn. *Yancey:* Mt. Mitchell, 4, BS. **Tennessee.** *Sevier:* Great Smoky Mountains National Park, Upper Greenbrier Cove, 6, CAS, 1, Conn. **Virginia.** *Augusta:* Elliott Knob, 1, BS; George Washington National Forest, 1 (skeleton), LL. *Giles:* Mountain Lake, 1, PRR. *Grayson:* White Top Mt., 1, Conn. *Montgomery:* Blacksburg, 1, CM. **West Virginia.** *Monongalia:* Morgantown, 1, CM. *Nicholas:* Gilboa, 1, NM. *Pocahontas:* Cranberry Glades, 1, BS; Cranberry River, 1, BS; Travelers Repose, 4, BS. *Preston:* Terra Alta, 4, CM.

Synaptomys cooperi helaletes Merriam

Synaptomys helaletes Merriam, Proc. Biol. Soc. Wash., 10: 59, 1896.

Synaptomys cooperi stonei, Rhoads and Young, Proc. Acad. Nat. Sci. Phila., p. 307, 1897, part.

Synaptomys helaletes helaletes, Miller, U. S. Nat. Mus. Bul. No. 128: 394, 1924.

Synaptomys cooperi helaletes, Howell, North Amer. Fauna No. 50: 17, 1927.

Type locality.—Lake Drummond, Dismal Swamp, Norfolk County, Virginia.

Range.—Coastal swamp areas of southeastern Virginia and northeastern North Carolina. Problematic occurrence northward along coastal Virginia to Maryland.

Diagnosis.—The skull of *S. c. helaletes* has a comparatively wide rostrum and upper incisors (Table 1); comparatively wide zygomatic arches, with ratio to condylobasilar length of .68; and nasal width comparatively narrow as compared to width of upper incisors, with an index of .88 in the specimens examined. The following measurements from ten adult *S. c. helaletes* are selected to show the characteristics of the skull of the race: width of incisors, 4.0 ± .03 mm. (range 3.8–4.5 mm.); nasal width, 3.5 ± .07 mm. (range 3.2–4.0 mm.); rostral width, 6.3 ± .07 mm. (range 6.0–6.6 mm.); condylobasilar length, 25.1 ± .20 mm. (range 24.4–26.0 mm.); zygomatic width, 17.1 ± .22 mm. (range 16.2–18.2 mm.); height of skull, 10.5 ± .17 mm. (range 10.0–11.1 mm.). No significant differences were seen in pelage between this form and *S. c. stonei*.

Comparison.—This form, apparently isolated from other *Synaptomys cooperi*, was found to differ significantly (by one standard error or more) from the closest race, *stonei*, in seven of the measurements taken: greater—width of upper incisors, rostral width, length of maxillary tooth row, condylobasilar length, nasal length, and height of skull; shorter—incisive foramen. Of the foregoing measurements only the widths of the rostrum and upper incisors were larger than two standard errors of the mean from this similar upper limit for *stonei*. The mean length of the incisive foramen was two standard errors shorter than the two standard error limit for *stonei*. The remaining eight diagnostic measurements of skull and body did not differ significantly from those of *stonei*.

Remarks.—From the foregoing comparison of *S. c. helaletes* with *S. c. stonei*, it is apparent that *helaletes* does not differ so greatly from the nearest form as do the other subspecies. This close relationship with *stonei* is indicative of its origin from the latter form after the loss of interconnecting range. This isolation may well have been accomplished by marine encroachment upon the intervening range as well as habitat destruction by white man.

Specimens examined.—Total, 13, as follows: **North Carolina.** *Perquimans:* Chapanoke, 1, Phil, 1, BS. **Virginia.** *Norfolk:* Dismal Swamp, Lake Drummond, 10, BS, 1, NM.

Synaptomys cooperi gossii (Coues)

Arvicola (Synaptomys) gossii Baird, Mss, *ex.* Coues, Proc. Acad. Nat. Sci. Phila., p. 194, 1874.

Synaptomys helaletes gossii Merriam, Proc. Biol. Soc. Wash., 10: 60, 1896.

Synaptomys cooperi gossi, Rhoads and Young, Proc. Acad. Nat. Sci. Phila., p. 307, 1897.

Synaptomys cooperi gossii, Howell, North Amer. Fauna No. 50: 18, 1927.

Synaptomys cooperi saturatus Bole and Moulthrop, Sci. Publ. Cleveland Mus. Nat. Hist., 5: 149, 1942, part (type loc.: Bloomington, Illinois).

Type locality.—Neosho Falls, Woodson County, Kansas.

Range.—The grass areas of central and southern Illinois, the driftless area of Wisconsin, Iowa, eastern Nebraska (Lancaster County), Missouri, eastern Kansas, and northeastern Arkansas. West of this line there may be unreported isolated colonies similar to the record from Valentine, Cherry County, Nebraska, west of the central part of the state, and from Little Salt Marsh, Stafford County, Kansas, reported by Cockrum (1952). Marginal records in Iowa include Dickinson County (Stephens, 1922) and Lynn County (Stoner, 1918).

[A record of *S. c. gossii* in extreme southwestern Nebraska (4 mi. N., ½ mi. E. of Octavia, Butler Co.), as well as two new county records in eastern Nebraska (Parks, Dundy Co.; Pleasant Dale, Seward Co.), has recently been reported by J. Knox Jones, Jr., Univ. Kan. Publ., Mus. Nat. Hist. 7: 486, 1954.]

Diagnosis.—Body and skull quite large (Table 1) as illustrated by the following measurements of 98 adult *S. c. gossii* from throughout its range: Width of incisors, 3.8 ± .02 mm. (range 3.3–4.3 mm.); nasal width, 3.7 ± .02 mm. (range 3.0–4.3 mm.); condylobasilar length, 26.1 ± .09 mm. (range 23.6–28.6 mm.); zygomatic width, 17.2 ± .05 mm. (range 15.0–18.5 mm.); and height of skull 11.1 ± .05 mm. (range 10.0–12.7 mm.). The widths of nasals and upper incisors are about equal (index of .95–1.00 in specimens examined). The specimens from Kansas and Nebraska are slightly darker and more reddish than specimens from Illinois. The darker, chestnut colored individuals, although present throughout the year in both sexes, are more frequent in spring and fall series of specimens from Kansas, Missouri, and Illinois. The slight ochre wash on the silver venter, often noticeable throughout the species, was more apparent in *gossii* from Kansas than in specimens from Illinois. Individually, however, specimens from the eastern and western portions of the range of the subspecies could not be distinguished.

Comparison.—See comparison of *S. c. cooperi* with *S. c. gossii*. The specimens from the eastern and northern borders of the range of *gossii* (southwestern Wisconsin and in Illinois) tended to be smaller than those from Kansas and Nebraska. However the means of the measurements of these eastern and northern *gossii* are still significantly different (two S. E. or more) from the nearest *cooperi*, in northern Wisconsin, Indiana, and Michigan. The

dimensions of the skulls of *gossii* as compared to *cooperi* tend to be proportionately larger. The exceptions include equal or near equal widths of upper incisors and nasals for *gossii*, with generally smaller nasal to upper incisor ratios for *cooperi* (except for specimens from Indiana); and higher crowned skulls for *gossii* (height of skull to condylobasilar length index of .43 for specimens examined). Dark chestnut forms were found more frequently in the specimens of *gossii* examined than in either the series of *cooperi* or *stonei*. *S. c. gossii* differed significantly (by at least two standard errors) from *S. c. paludis* in all of the measurements used except for: length of tail, length of maxillary tooth row, length of incisive foramen, and nasal width. The smaller dimensions of the skull of *gossii* as compared to *paludis* were generally proportionate except for *gossii* having relatively larger nasal width as compared to width of upper incisors and relatively longer nasals as compared to nasal widths.

Remarks.—The name *gossii* was first reported by Coues (1874) as "*Arvicola* (*Synaptomys*) *gossii*, MS, Baird" as a synonym of *Synaptomys cooperi* (Baird). Coues (1877: 235) stated that Baird had used the name on the labels of the Neosho Falls, Kansas, specimens "in anticipation of their proving different from the original *cooperi*." As Coues did not name subspecies of *S. cooperi* and merely found the Kansas forms inseparable from the species, Merriam (1896) held that *gossii* (Baird) *ex.* Coues was a *nomen nudum* and so published *S. helaletes gossii* Subsp. nov. Howell (1927) correctly gave priority to *Synaptomys cooperi gossii* (Coues).

A gradient was generally observable, from larger to smaller, west to east, in the range of *S. c. gossii* (see Figs. 2–5). Specimens from the western fringe of the range, such as in Nebraska, are similar to *S. c. paludis* to the extent of having prominent interorbital and frontal ridges.

Reasons for synonymizing *saturatus* have been presented earlier in this paper.

Specimens examined.—Total, 177, as follows: **Arkansas.** *Craighead:* Lake City, 1, BS. **Illinois.** *Champaign:* Urbana, 1, Ill, 1, INHS; Mahomet, 1, Ill. *Coles:* Charleston, 5, TAS *Crawford:* Flat Rock, 3, CAS. *De Witt:* White Heath, 1, Ill. *Fulton:* Vermont, 1 (alc), INHS. *Hardin:* Rosiclare, 10, CNHM. *Marion:* Odin, 1, BS. *McLean:* Bloomington, 1, ClM; Le Roy, 2, Ill. *Perry:* Pinckneyville, 2, SI. *Piatt:* Allerton Park, Monticello, 57 (2 skulls only and 1 skeleton only), Ill. *Richland:* Olney, 13 (skulls from owl pellets), INHS. *Saline:* Eldorado, 1 (alc), Ill. *Sangamon:* Auburn, 1, Ill. *Union:* Alto Pass, 1 (skull from owl pellet), Ill. *Vermilion:* Kickapoo State Park, 5 (2 skulls only), CNHM, 3 (1 skull only), Conn; Muncie, 1, INHS (reported as *Microtus pennsylvanicus*, Necker and Hatfield, 1941). **Iowa.** *Henry:* Hillsboro, 1, BS. *Marion:* Knoxville, 1, NM. **Kansas.** *Atchison:* Muscotah, 6, KU. *Douglas:* Lawrence, 13 (1 skull only), KU. *Leavenworth:* Ft. Leavenworth, 2, BS. *Nemaha:* Sabetha, 6, KU. *Woodson:* Neosho Falls, 1 (skull only), NM. **Missouri.** *Boone:* Ashland, 2, Mo; Columbia, 4, PU, 2, Cinc, 1, Mo; Midway, 9, Mo; Turner, 1, Mo. *Cooper:* Bellair, 1, Mo. *St. Charles:* Horseshoe Lake, 5 (1 skull only), BS, 1 (skull only), PRR. **Nebraska.** *Cherry:* Valentine, 1 (skin only), NEB. *Lancaster:* Lincoln, 5, NEB, 2, NM. **Wisconsin.** *Crawford:* Lynxville, 1, BS.

Synaptomys cooperi paludis Hibbard and Rinker

Synaptomys cooperi paludis Hibbard and Rinker, Univ. Kansas Sci. Bul., 28: 25, 1942.

Type locality.—Meade County State Park, 14 miles southwest of Meade, Meade County, Kansas.

Range.—Known only from the type locality.

Diagnosis.—A distinct, large form (Table 1) as indicated by the following measurements of eight *S. c. paludis:* width of upper incisors large, with a mean of 4.5 ± .06 mm. (range 4.3–4.8 mm.); nasal width smaller than width of upper incisors, with a mean of 3.9 ± .12 mm. (range 3.4–4.4 mm.); condylobasilar length, 28.3 ± .18 mm. (range 27.8–29.2 mm.); zygomatic width, 18.9 ± .19 mm. (range 18.0–19.6 mm.); height of skull, 12.0 ± .14 mm. (range 11.3–12.5 mm.). The lambdoidal dimension and width of the upper incisors contribute to the impression of massiveness received from examination of the skull. The other dimen-

sions of the skull tend to be proportionately larger than *gossii*. Due to the size of the skull, interorbital ridges are extremely developed in adults.

Comparison.—*S. c. paludis* is distinctly larger (by two standard errors) than *S. c. gossii* from Kansas, except for length of tail, length of maxillary tooth row, length of incisive foramen, and nasal width. Due to the similar nasal widths combined with the larger width of incisors for *paludis*, the nasal width to width of incisors index is well below 1.00 (.87 for the adult specimens examined). This may be compared to the near equality of these two measurements for *gossii* from Kansas and elsewhere in its range. Similarly the nasal width to nasal length index for *paludis* is lower (.45 for specimens examined) than that of *gossii* from Kansas (.48 for specimens examined). The greater lambdoidal width of *paludis* is indicated by the lambdoidal to zygomatic width index of .77 which was obtained for *plaudis* and .79 in the *gossii* from Kansas.

Remarks.—*S. c. paludis* is the most sharply differentiated race of Recent *Synaptomys cooperi*. The extreme position is, of course, accentuated by the geographical separation of *paludis* from the specimens of *gossii* examined from eastern Kansas. A gradation from Meade County to eastern Kansas would perhaps be observable could the geographical gap be spanned by series of specimens. The isolated colony of *paludis* in Meade County is, in the sense of its larger dimensions, a relic of late Pleistocene. Its persistence can be explained by the permanence of the marshes in which it is found.

Specimens examined.—Total, 12, as follows: **Kansas.** *Meade:* Meade County State Park, 14 Mi. SW Meade, 12, KU (10 paratypes).

SUMMARY

A total of 686 specimens was examined in studying the speciation and dispersal of the southern bog lemming, *Synaptomys* (*Synaptomys*) *cooperi* (Baird). Data accumulated from thirteen measurements of skull and three measurements of body were individually mapped as well as treated statistically. This treatment indicated few discrete characters separating the subspecies of this subgenus. These geographical units were observable, however, as modal trends of continuous variables or as dispersal gradients reflecting the history of speciation.

Three suprasubspecific groups were found within the subgenus *Synaptomys*. The *gossii* group includes *S. c. gossii* (Coues) occupying the southwestern portion of range of the species and *S. c. paludis* Hibbard and Rinker, a conservative or localized relic race to the west of *S. c. gossii* in Kansas. The *stonei* group includes *S. c. stonei* Rhoads which occupies the southeastern portion of the range of the species and *S. c. helaletes* Merriam, a coastal swamp remnant of the *stonei* group in eastern Virginia and North Carolina. The *cooperi* group occupies the northern part of the range of the species as a single subspecies.

S. c. saturatus Bole and Moulthrop was held invalid on the grounds of its being an artificial unit embracing two distinct and separable portions of the ranges of *S. c. gossii* on the west and *S. c cooperi* on the east. The coloration regarded as typical of *saturatus* by Bole and Moulthrop (1942) was found in specimens of *gossii* from Kansas as well as in other series of specimens from outside the range of *saturatus*. The logic of the assumptions made in establishing this form rest upon the somewhat atypical nature of the two subspecies concerned, at their point of intergradation. These midwestern specimens displayed a closer relationship to their parental stocks than to a single common unit, *S. c. saturatus*.

In postulating the direction of speciation and dispersal of Recent forms of *Synaptomys cooperi* it was assumed that dispersal had occurred from populations of larger forms located in areas free of the last glacial advance. That two dispersal centers were present at the time of the glacial retreat was considered probable due to the extensive Mississippi-Ohio glacial drainage through the center of the range of the species. From these two dispersal centers, that of *gossii* on the southwest and *stonei* on the southeast, repopulation of the area left by glacial retreat was considered to have occurred. Such areas were seen to be coexistent with the range of *S. c. cooperi* as they are roughly comparable to the extent of the Wisconsin glacier. It was speculated that this northward dispersal of the southern bog lemming was met at its northern margins by the dispersal of the northern bog lemming, *Synaptomys borealis* (Richardson), eastward from the Rocky Mountains.

An evident reduction in the range of *Synaptomys cooperi*, following these post glacial movements, was noted. This was seen in the western margins of the range of the *gossii* group, in the establishment of *S. c. helaletes* as a form separate from *S. c. stonei*, as well as more recent reduction of optimum habitats throughout the range of the species to the level of existence, over most of the area, as isolated colonies.

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POPULATION STUDIES ON SOME SMALL FOREST MAMMALS IN EASTERN CANADA

By R. F. Morris

Studies in Eastern Canada on the European spruce sawfly, *Diprion hercyniae* (Htg.), showed that predation by small mammals was the most important factor affecting cocoon populations of this insect. The entomological aspects of these studies have been presented by the writer (1942), as have also the data on feeding habits (1949). The present paper, which is restricted to population techniques and to trapping results in different forest habitats, is the final paper dealing with the project. This is contribution No. 146, Division of Forest Biology, Science Service, Department of Agriculture, Ottawa, Canada.

The data were obtained in 1941 in central and southern New Brunswick and in the central part of the Gaspé Peninsula, Quebec. A new approach to extensive population sampling was used but as the project had to be discontinued after 1941, there was no opportunity to test its underlying assumptions. Publication of results has been delayed, partly in the hope that current literature on small mammals would provide data relevant to these assumptions.

A complete list of the mammals occurring in this region has already been presented by the writer (1948). The present paper is concerned with the following species, and particularly with the red-backed vole and the deer mouse: Red-backed vole, *Clethrionomys gapperi ochraceus* (Miller) in New Brunswick and *C. g. gaspeanus* Anderson in the Gaspé; deer mouse, *Peromyscus maniculatus abietorum* (Bangs); cinereous shrew, *Sorex cinereus acadicus* Gilpin in New Brunswick and *S. c. cinereus* (Kerr.) in the Gaspé; short-tailed shrew, *Blarina brevicauda pallida* Smith in New Brunswick and *B. b. angusta* Anderson in the Gaspé; pigmy shrew, *Microsorex hoyi thompsoni* (Baird) in New Brunswick; forest meadow vole, *Microtus pennsylvanicus fontigenus* Bangs in the Gaspé; and woodland jumping mouse, *Napaeozapus insignis insignis* (Miller) in New Brunswick.

GENERAL APPROACH

Small-mammal populations have generally been studied by either of two methods. One method employs snap-traps, which are usually set at close but irregular intervals throughout a quadrat of known size. The traps are examined and reset daily, and a period of three or four nights is considered sufficient by most workers for the removal of the resident population. The other method employs live-traps, which are set in the form of a grid with constant intervals between traps. The mammals are marked and released each morning and trapping is generally continued until only marked individuals are caught. The two methods are sometimes referred to as the "removal method" and the "mark-and-release method."

Bole (1939) made a detailed study of the snap-trap method and revealed such weaknesses as the arbitrary length of the trapping period, the possibility of influx from adjacent areas as animals are removed, and the dependence of re-

sults on quadrat size. A more serious weakness has been shown by Burt (1940) and others. With the aid of live-traps and a marking system that permitted the recognition of individual animals, it was demonstrated that small mammals have definite home ranges and that the area of the home range is rather large for most species. Hence, the traps on a quadrat take not only the resident population of the quadrat but also many animals whose home ranges lie largely outside the quadrat. The area actually sampled is equal to the trapping quadrat plus a strip on all sides equal in width to the mean radius of the home range. Populations per acre based on snap-trapping without consideration of home range tend to be greatly over-estimated. In recent years, therefore, most population students have adopted the live-trap technique. But this, too, has its disadvantages. Live-trapping and marking are very time-consuming in relation to snap-trapping, and large numbers of live-traps are awkward to transport in the field. Thus most studies have been limited to rather small areas that are readily accessible. Another difficulty is that a few species, such as the cinereous shrew, rarely survive overnight in ordinary types of live-traps.

One of the objects of the present study was to determine the influence of silvicultural practices on small-mammal populations, and hence on the resulting insect control. Trapping was required in many different stands, some of which were relatively inaccessible. At the same time, population per acre was required rather than some purely relative index. In ecological research it is particularly desirable to express the populations of all animals in terms of a common and absolute unit, such as the acre. If insect and predator populations are expressed in different sampling units, or in purely relative units, any mathematical interpretation of their interactions is seriously limited.

To satisfy these objectives, a combination of live-trapping and snap-trapping was tested in 1941. It was considered that the periodic use of live-traps on one centrally-located plot would reveal the number of trapping nights required, the size of the home range of the common species, and the population trend throughout the season. Using the data from live-trapping on these three factors, it should then be possible to derive per-acre estimates for extensive snap-trapping conducted at various times during the same season. Snap-traps were therefore used on all plots except one, but to facilitate comparisons they were always set in grids with the same spacing as the live-traps. There are three major assumptions in this approach:

1. That snap-traps, when arranged in exactly the same way as single-catch live-traps, are neither more nor less efficient in capturing small mammals. If this is true, then the number of nights required to catch all, or a known proportion of, the population can be determined from live-trapping and applied to snap-trapping.

2. That the mean home range for each species is relatively constant in the different habitats that are sampled. If true, the home ranges determined with live-traps on the central plot can be used to compute the area sampled on the other plots.

3. That the population trend is similar in shape, but not necessarily in absolute values, in the different habitats. If this is so, then the results of all trapping

can be converted to a common reference point, such as the peak of the seasonal trend, regardless of the dates on which snap-trapping is done.

If these assumptions are found to be valid, even for relatively small regions or for a limited variety of habitats, the combination of live- and snap-traps should provide a useful technique for the study of small-mammal populations. The present study was only a part-time project of the writer during one field season and it is not considered that the data are sufficient to provide a reliable test of any of the assumptions. Therefore, their acceptance in the analysis of the 1941 data can be defended only on the probability that they provide more realistic population figures for extensive trapping than would any other method available at the time.

TRAPPING METHODS

The plot used for live-trapping, designated as Plot 1, was located in a coniferous stand at the Acadia Forest Experiment Station in central New Brunswick. This plot was trapped during the third week of each month from May to November, inclusively. The method of live-trapping was essentially the same as that described by Burt (1940) and Blair (1941*a*). The traps were spaced at intervals of 45 feet along lines that were 45 feet apart, the trap positions being permanently marked. At first, 64 traps (8 x 8 grid) were used, covering an area of 2.28 acres. It was soon discovered that this area was much too small to provide adequate data on ranges, so the number of traps was increased to 195 and the area to 7.82 acres (Fig. 1).

The construction of the single-catch live-traps has already been described (Morris, 1943). Many preliminary tests were made with different baits, and peanuts proved to be as effective as anything else for both rodents and shrews

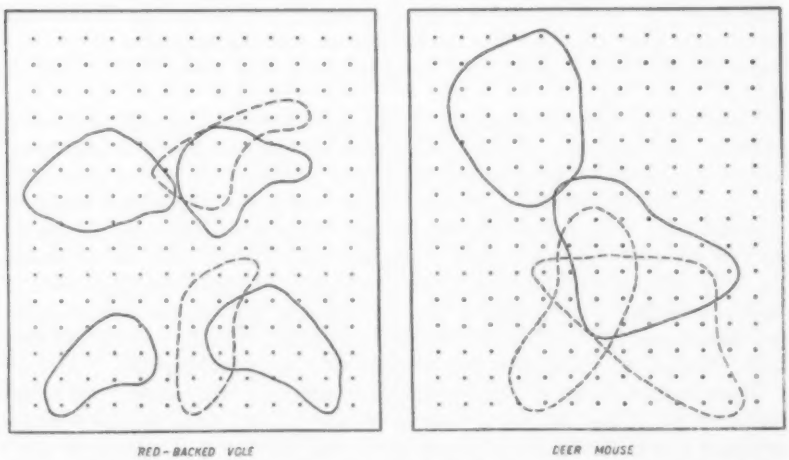

FIG. 1.—Shape of the home range for six red-backed voles and four deer mice on Plot 1. Dots indicate the positions of the live-traps, which were spaced at intervals of 45 feet.

in this region. Peanuts in the shell were used in live-trapping and peanut butter in snap-trapping. Live-traps were provided with cotton nesting material. Traps were set in the late afternoon or early evening and visited as soon as possible after daybreak. The system of numbering described by Burt (1940), in which small ear notches made with a poultry punch permit any combination of numbers up to 400, was adopted in the present work.

Very few deer mice died in the traps. The red-backed vole is more sensitive to trapping. Through its particular activity rhythm (Morris, 1944), it is also more active in daylight hours than the deer mouse. Therefore, if the traps are set too early in the day, the voles may be caught immediately and have to spend a relatively long interval in captivity. Only by setting the traps just before dark and releasing the animals soon after daybreak can trap mortality for this species be kept at a negligible level. The cinereous shrew was almost invariably found dead in the traps.

The area of the plots used for snap-trapping was generally 2.28 acres, with 64 traps spaced at 45-foot intervals in an 8 x 8 grid. A uniform habitat was selected for each plot and the plot was so located that a buffer strip of 200 feet, representing the same habitat, occurred on all sides. A trapping period of three nights was used on these plots.

NUMBER OF TRAPPING NIGHTS REQUIRED

Most mammalogists who have studied population by using snap-back traps have used an arbitrary trapping period of three nights. The fact that the nightly catch declines rather sharply after the third night has led to the belief that animals taken in subsequent nights are more likely to be migrants than residents.

On Plot 1, where only live-traps were used, it was generally necessary to trap for six nights before all the animals were marked. The number of unmarked mice taken on each successive night, expressed as a percentage of the total population, was as follows. For the red-backed vole the successive percentages were: 32; 29; 24; 7; 7; and 1. For the deer mouse they were: 27; 38; 25; 7; 2; and 1.

These figures represent means for the trapping periods in August, September, October, and November. During these periods the population was comparatively stable; the earlier trapping periods have been omitted because the population was increasing rapidly and may have changed during the six nights of trapping. The above percentages show that 85 per cent of the red-backed voles and 90 per cent of the deer mice were taken in the first three nights. This can be broken down by months, recalling that the trapping period occupied the third week of each month. For the red-backed vole the monthly percentages were: August, 90; September, 76; October, 96; and November, 93. For the deer mouse they were: August, 83; September, 94; October, 93; and November, 90.

These results do not show any significant variation with season; the colder nights of November did not appear to reduce activity or to require a longer trapping period. With traps spaced at 45 feet, therefore, a reasonably good estimate of population can generally be obtained by trapping for three nights and multiplying the results by 100/85 or 100/90.

The question now arises as to whether this rapid method for estimating populations after three nights is equally applicable when snap-back traps are used instead of live-traps. In other words, is Assumption 1 valid? Since snap-trapping removes the captured animals, one might expect, (a) a greater probability of capture after the first night because no traps can be occupied by marked, recaptured individuals, and (b) a possible influx of animals on the second and third nights resulting from the decrease in population density on the trapping quadrant. To test Assumption 1, Plots 2 and 3 were established in the same habitat as Plot 1, just far enough away to prevent any possible interference among any of the three plots. After three nights of snap-trapping, the above correction factors were applied and the results compared to those for Plot 1. Populations per acre for the deer mouse and red-backed vole were as follows: Plot 1—6.5, Plot 2—6.0, Plot 3—6.0. Contrary to expectations, the snap-trapping gave slightly lower rather than higher results. Also, there was no indication that snap-trapping took relatively more animals in the second and third nights. Assuming, for the moment, that the catch of the first three nights represents 100 per cent, the percentage composition by successive nights is as follows: For live-traps, 34, 38, and 28; for snap-traps, 43, 32, and 25.

These data are too limited, of course, to permit a conclusive statistical test. However, in analysing the snap-trapping results, Assumption 1 is accepted with the belief that it probably does not lead to errors inconsistent with the level of accuracy of the whole method.

SIZE OF HOME RANGE

The home range is the area over which an animal normally travels. For small mammals, there is a wide overlapping among adjacent ranges, not only for different species but for different individuals of the same species. The concept is therefore quite different from the concept of territoriality in birds (Burt, 1943).

Since the writer's field work was done, the concept and measurement of home range have been examined rather critically. Hayne (1949*a*) reviews the different methods of calculating the areas of home ranges and suggests that two types of ranges be recognized—the true, or biological, home range and the trap-revealed range. He states, "Even when dealing only with the trap-revealed range, it seems necessary to accept the edges of the apparent area as shading off on the basis of probability of capture and not as discrete lines of biological validity." For *Microtus*, the trap-revealed range seemed to be larger when the distance between traps was increased (Hayne, 1950). This suggests that live-traps, when closely spaced, so interfere with movement that an animal is unable to cover its whole range during the trapping period. Presumably, errors of this type will be highest when, (1) traps are rather closely spaced, (2) the trapping period is brief, and (3) the population level is low, i.e., the traps are competing for animals rather than the animals competing for traps. In the present study, the trap-revealed range for any individual increased rather sharply until about seven captures were recorded, and then remained relatively constant. As pointed out by Hayne (1949*a*) this in itself is not proof that the true range has been demon-

strated. However, trapping was continued periodically from May through November and, except for a very few animals that appeared to shift the position of the range, the trap-indicated range did not become progressively larger as the season progressed. The animals had an opportunity to move freely over the ranges not only between trapping periods but during the hours each day when the traps were unset. Four species of small mammals were trapped on Plot 1 and, at the peak of the seasonal population trend, the situation represented essentially a competition of animals for available traps. It was not uncommon for an animal to be caught at opposite extremities of its range on two successive nights, possibly because many of the intervening traps were occupied by other animals. Thus, in calculating the probability of capture of an animal at successively greater distances from its center of activity (assuming that there is a biological center of activity), it is not realistic to assume that it is surrounded by empty traps. Undoubtedly, much fundamental work remains to be done on the biological significance of the home range and on the measurement of its area. For present purposes it is necessary to assume that the trap-revealed ranges on Plot 1 represent true ranges. At least, for the type of trapping done in 1941, it has not yet been demonstrated that this assumption is false.

Home ranges were plotted separately for each trapping period on Plot 1 and then, as few individuals showed any shifting in the position of the range between May and November, the maps for all periods were combined to give the best estimate for each animal. Stickel (1946) believes that this pooling of home range data for different periods is open to question, because "... *the actual movements of the animals in the given area in the given period* are the items of importance in attempting to derive figures on populations." This is quite true, of course, but does not make allowance for the possible interference of the traps with normal movements, particularly when the given period is rather short. The only reason for determining home range in population work is to permit the calculation of the strip that has been sampled on the outside of the trapping quadrat. In this outside strip there are no traps to hinder movement. However, Stickel's objection is valid if the home range varies in size, or in intensity of use, at different periods in the season. The present data suggest a rather consistent range between May and November, but are too limited to provide conclusive evidence on this point.

Once the trapping records are plotted, the approximate boundaries of each animal's range may be drawn in by eye (Fig. 1), or the area may be calculated by one of the more objective methods now available (Hayne, 1949*a*). The writer has used the summation of "trap units" proposed by Blair (1940). If an animal is caught in one trap it is statistically correct to assume that, on the average, its range extends one-half the distance to the nearest trap in which it is not caught. In the present case, therefore, a trap unit is a 45-foot square. The different traps in which the animal is taken are counted, plus any intervening traps, and the total is multiplied by the area of a 45-foot square.

The great majority of the animals caught and marked on Plot 1 had ranges that extended beyond the trapping area, and had to be excluded from the calcu-

lations. Others, particularly juveniles that had recently left the nests, were caught only a few times before they disappeared from the plot. They have been excluded, along with any others caught less than seven times.

For 15 red-backed voles (8 males, 7 females), the mean size of the home range was 0.60 ± 0.03 acres, with extreme values of 0.37 acres and 0.93 acres. The mean radius of this area ("cruising radius") was 91 feet. For 13 deer mice (7 males, 6 females), the mean area was 1.27 ± 0.08 acres, with extremes of 0.74 acres and 1.67 acres. The cruising radius was 131 feet. Most investigators have found that the range of the male is greater than that of the female. The present data do not show this, possibly because the number of measurements is too small.

The shape of the home range varies from nearly circular to elliptical or triangular (Fig. 1). There was no animal on the plot whose range did not overlap considerably with the ranges of several other animals of the same or other species, or of the same or the opposite sex.

The second major assumption upon which the present method is based is that the size of the home range is the same in different habitats. Several authors have mentioned the possibility that range size may vary with habitat, available food supply, population density, or season of the year. However, this subject has received very little study. Blair (1940) found that male meadow mice had a somewhat smaller range in moist than in dry grassland. Stickel (1948) found that wood mice, *Peromyscus leucopus*, living in uplands had larger ranges and smaller populations than those living in bottomlands. The upland and bottomland habitats were not described but presumably they were rather distinctly different. On the basis of these two papers, it must be considered that Assumption 2 is very much open to question. However, work on this subject has been much too limited to permit any appraisal of the magnitude of error likely to result from this assumption under the range of habitats sampled during the 1941 work. More recent studies, still in progress, suggest rather similar range sizes in coniferous forests in northern and in central New Brunswick.

POPULATION CYCLES

Small-mammal populations show two types of cycles—a seasonal cycle within each year and a longer cycle with peaks occurring at intervals of a few years.

The lowest point in the seasonal cycle occurs in the early spring, before the breeding season starts. Population then increases rapidly to reach a peak in late summer or early fall. After the cessation of breeding activity in the fall, the population declines, as the result of predation and other factors, until breeding starts again the next spring. One female may produce several litters during the breeding season, and females born in the spring or summer may start to breed during the same season. There are four or five in most litters. Figure 2 shows the seasonal population trends for the red-backed vole and the deer mouse on Plot 1. From a population per acre of 0.5 or less in late May, the peak of the seasonal cycle is reached with populations of 3 or 4 per acre in the fall. The average longevity for these species is therefore considerably less than one year and only a

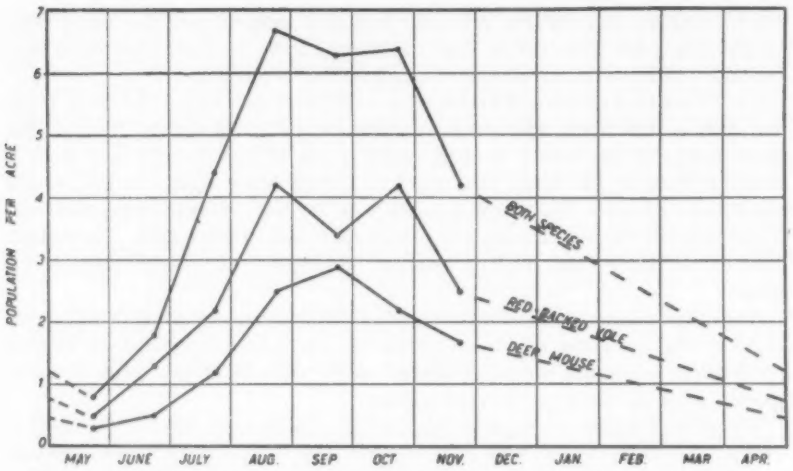

FIG. 2.—Seasonal population trend for the deer mouse and red-backed vole on Plot 1. Broken portions of the trends are hypothetical.

very small proportion of the animals born in one season survive to the beginning of the next breeding season.

In 1941 the breeding season appeared to be about the same for both of these species. Trapping was started on May 7 and continued until the end of November. Until the middle of June, only adult animals that had overwintered were taken, but it was evident that breeding had started in May. As nearly as could be determined, the first litters left the nests in the second week of June in New Brunswick and a week or two later in the Gaspé. The latest records for lactating females and for juvenile specimens that had just left the nests were obtained on October 25 in New Brunswick. For some of the small mammals studied in Michigan, it was reported that peaks of breeding occurred in spring and fall and that the rate of breeding declined somewhat in mid-summer (Burt, 1940). Whether the September depression in the population trend for the red-backed vole was a result of this factor is not known. The sex ratio, as based on all animals captured during the season, showed 47 per cent females for the red-backed vole and 48 per cent females for the deer mouse.

For the purposes of the population estimates, the period between the third week in August and the third week in October has been accepted as the peak period of the seasonal cycle. For the two species combined, the mean population during this period on Plot 1 was 6.4 mice per acre (Fig. 2). In the third week of July, for example, the combined population was 4.4; so for plots on which snap-back traps were used in the third week of July the results were multiplied by the ratio 6.4/4.4 in order to refer all results to the peak period of population and hence to permit direct comparisons among plots. This assumes that the shape of the seasonal trend was the same on all plots (Assumption 3). No in-

formation was obtained in 1941 on the validity of this assumption, nor have any relevant data appeared meanwhile in the literature. In fact, very few attempts have yet been made to determine the seasonal cycle, even on one plot. As in the case of Assumption 2, however, results corrected according to the data for Plot 1 are likely to permit more realistic comparisons than they would if the seasonal cycle were entirely disregarded. At the same time, it is clear that May and June are the poorest months for snap-back trapping; because of the low population level in the spring, small errors are magnified when results are converted to peak estimates.

No information on the longer population cycle is provided, of course, by one season's trapping. From other work, however, it seems probable that 1941 was intermediate between low and peak population years. On the Green River Watershed in northern New Brunswick, live-trapping has been carried out annually since 1947 on a number of permanent ecological plots This work will be continued for some years before results are presented, but populations of the red-backed vole between 1947 and 1953 suggest a three-year cycle with peaks in 1948, 1951, and another anticipated in 1954. If this cycle is constant, it would suggest peaks in 1945 and 1942.

RELATION OF POPULATION TO FOREST CONDITIONS

Table 1 shows the results of population studies on 21 plots in 1941, as well as the plot descriptions. Only ocular estimation was used in rating the various factors of the habitat and the descriptions are therefore more comparative than absolute. Where snap-back traps were used (Plots 2–21), the population results have been corrected according to the seasonal cycle and to the percentage of the population not captured in three nights. These corrections are illustrated above. The cruising radius determined on Plot 1 has been applied to all plots. Thus, for an 8 x 8 grid of traps covering an area of 2.28 acres, the area actually sampled is about 5.6 acres for the red-backed vole and 7.5 acres for the deer mouse. Because of the scarcity of the short-tailed shrew on Plot 1, its cruising radius was not determined. In reviewing available live-trapping data on this species in Michigan, Blair (1941*b*) concludes that the home range usually exceeds one acre. The effective trapping area for the deer mouse has therefore been used for the short-tailed shrew and also for the cinereous shrew. Pending more adequate information on these two species, the estimates of population per acre must be accepted with reservations.

The red-backed vole is by far the predominant species, particularly in softwood sites. Trapping in northern New Brunswick between 1947 and 1953 shows the same predominance of this species, and it seems safe to conclude that the species composition shown in Table I is reasonably typical of coniferous forests in this region. The short-tailed shrew is generally rare in softwood stands but more common under mature hardwoods (Plots 15, 16), where the thick leaf mould facilitates tunnelling, and on Plot 21 in the Gaspé where there is a deep layer of moss.

The most interesting ecological relationship shown by Table 1 is the de-

TABLE 1.—*Results of small-mammal population studies in various forest habitats in 1941*

Plot[1] No	Stand			Ground cover[5]					No per acre at seasonal peak[11]				
	Spp.[2]	Age[3]	Crown[4] closure	Debris[6]	Ferns[7]	Herbs[8]	Moss[9]	Leaf litter[10]	R.-b vole	Deer mouse	Clear. shrew	Sh.-t shrew	Total
1	Sw, Fb	M	2	3	1	2	2	2	3.9	2.6	1.6	0.1	8.2
2	Sw, Fb	M	2	3	1	2	2	2	4.5	1.5	1.2	—	7.2
3	Sw, Fb	M	2	3	1	2	2	2	4.1	1.9	1.6	0.3	7.9
4	Sb	M	2	2	2	2	2	1	2.9	1.5	3.7	0.3	8.4
5	Sb	S	1	0	0	1	3	0	—	—	1.3	—	1.3
6	Sw, Fb	S	2	3	1	2	2	2	9.2	0.6	—	—	9.8
7	Sw, Fb, Bw	S	3	1	0	0	0	3	3.9	0.6	—	—	4.5
8	Sw, Fb	S	3	1	2	1	2	2	3.1	—	0.5	—	3.6
9	Bw, Ms, Sw	S	1	1	3	2	0	3	0.6	—	—	—	0.6
10	Bw, Sw	M	1	1	3	1	1	2	—	—	—	—	—
11	Sw, Fb	S	2	2	2	2	2	2	3.8	1.6	—	—	5.4
12	Sw, Fb	M	2	2	1	1	1	2	3.1	0.8	0.5	0.8	5.2
13	Sw, Sr, Fb	M	3	1	1	0	0	3	0.9	—	0.2	0.2	1.3
14	Lt	M	2	0	0	1	3	0	—	—	—	—	—
15	aBe, By	M	2	1	1	1	0	3	—	1.5	—	4.2	5.7
16	He, aBe	M	2	2	1	2	0	3	2.1	1.0	—	2.9	6.0
17	Sw, Fb	M	2	2	1	2	2	2	5.9	—	—	—	5.9
18	Sr, Sb, Fb	M	2	2	1	3	3	1	1.1	0.8	—	—	1.9
19	Sb, Fb	M	2	2	1	2	3	0	5.3	1.8	7.2	—	14.3
20	Sw, Fb	M	1	3	1	2	2	1	6.9	—	4.6	—	11.5
21	Fb, Sb	M	2	2	1	1	3	0	10.4	—	—	4.6	15.0

[1] Nos. 1–10, Acadia Forest Experiment Station, Sunbury Co., N. B.; Nos. 11–14, University Woodlot, York Co., N. B.; Nos. 15–16, Fredericton City Woodlot, York Co., N. B., No. 17, Young's Brook, York Co., N. B.; No. 18, Lepreau, St. John Co., N. B.; Nos. 19–21, Cascapedia River, Gaspé, P. Q.

[2] Predominant tree species: Sw, white spruce; Sb, black spruce; Sr, red spruce; Fb, balsam fir; Lt, eastern larch; He, eastern hemlock; Bw, white birch; By, yellow birch; Ms, red maple; aBe, American beech.

[3] Age of stand: M, mature, height 50 feet or greater; S, second-growth, height 30–40 feet.

[4] Crown closure: 0, 0–5 per cent; 1, 5–25 per cent; 2, 25–75 per cent; 3, 75–100 per cent.

[5] Ground cover: 0, absent or practically so; 1, thinly scattered; 2, moderate in occurrence; 3, forming a predominant feature of forest floor.

[6] Debris: Fallen trees, decaying logs, brush from thinning or cutting operations, etc.

[7] Ferns: Generally bracken, especially in those plots where classified as abundant.

[8] Herbs: Common species in softwood sites were *Cornus canadensis* L., *Maianthemum canadense* Desf., *Clintonia borealis* (Ait.) Raf., *Linnaea borealis* L., *Coptis groenlandica* (Oeder) Fern., *Trientalis borealis* Raf.

[9] Moss: *Sphagnum* and *Polytrichum* on Plots 5, 14; predominantly *Calliergon*, *Hypnum*, *Hylocomium* on the others.

[10] Leaf litter: Refers to portion of forest floor having no vegetative cover.

[11] The following mammals are not included above: 4 pigmy shrews and 2 woodland jumping mice from Plot 1; 1 forest meadow vole from Plot 20.

pendance of small mammal populations upon cover, and particularly upon the type of cover afforded by debris, such as fallen trees, decaying logs, and slash from thinning or cutting operations. The New Brunswick plots in which debris was rated as Class 3 were all thinned a year or two prior to 1941, and the slash left on the ground. These plots had the highest populations of small mammals. Plots 6 and 7 represent a pair of plots in the same stand, which was originally mixedwood. On Plot 6 all the hardwood and some of the softwood was removed, while on Plot 7 the original stand was undisturbed. The increase in mammal population was over 100 per cent in the thinned stand. Mature softwood stands in which debris is provided through the action of blowdown and other natural factors, and in which the stand has opened up enough to encourage ground vegetation, are also well populated, as a general rule. Plot 18, for reasons that cannot be explained, provides an exception; collections of sawfly cocoons on this plot showed little evidence of predation by mammals, suggesting that the population had been consistently low for several years prior to 1941. Dense, second-growth stands, in which the forest floor is composed almost entirely of bare needle litter, are generally poor habitats (Plots 7, 8, 13). The results for Plots 9 and 10 suggest that a cover of tall bracken fern is not so effective as debris in encouraging mammal population.

The Gaspé plots had dead trees on the ground as a result of insect damage. Even in the absence of this cover it is probable that the deep moss layers characteristic of the softwood slopes (Plots 19, 21) would encourage high populations. The swaying of the trees creates openings and natural runways along the roots under the moss, and this provides excellent cover. Deep moss also occurred on Plots 5 and 14 in New Brunswick, but these plots were in black spruce and larch swamps which remained quite wet throughout the year. In the course of sawfly studies between 1932 and 1941, 82,000 cocoons examined in New Brunswick showed 19 per cent opened by small mammals, whereas 199,000 cocoons examined in the Gaspé showed 42 per cent. This difference in control agrees with the difference in population level (Table 1), especially with regard to the shrews.

Considering that the existence of small mammals is dependent upon their freedom to forage for plant and insect food without constantly exposing themselves to the eyes of owls, hawks, and other predators, the relationship between population and ground cover is not surprising. The diet of the rodents is so omnivorous that the foraging possibilities offered by the habitat are perhaps a secondary factor to cover. The population of sawfly cocoons had declined to a very low level on all plots by 1941, so there is little likelihood that small-mammal populations were affected by a super-abundance of insect food.

OTHER METHODS OF ANALYSIS

Since 1941, several mathematical or graphical methods for the analysis of data on both live-trapping and snap-trapping have been proposed. These methods will be examined very briefly to see whether the 1941 data satisfy their basic assumptions.

When live-trapping and marking are feasible, the "Lincoln Index" provides

a means of estimating total population without the capture of all individuals. Although it does not eliminate the major objections to live-trapping outlined above, it does permit shorter trapping periods providing certain requirements are satisfied and providing home range is already known. It is based on the simple equality, $x/p = m/t$, where x is the known number of marked animals in the population, p is the total population, t is the total number subsequently trapped, and m is the number of marked animals included in t. Thus, by solving for p, an estimate of population may be made after the second night of trapping. The Lincoln Index was first used for estimating populations of ducks, using banded birds reported by hunters, and has also been used in population work on fish, insects, and larger mammals. Hayne (1949*b*) discusses its application to small-mammal trapping; Adams (1951) shows the plotted confidence limits; and Bailey (1952) presents an interesting review of its application, with equations for calculating the variance of the population estimates.

One of the major assumptions in the application of the Lincoln Index is that the chances of capturing marked and unmarked animals are exactly proportional to their occurrence in the population. If marked animals tend to avoid traps, m becomes too low in relation to t, and consequently the estimate of p is in excess of actual population; similarly, if marked animals have a greater probability of capture, m becomes too high and p too low. For Plot 1 the calculated values of p, expressed as percentages of actual population (i.e., all animals marked in six nights) are as follows: For the red-backed vole—second night, 84 (68–95); third night, 85 (67–108); fourth night, 99 (85–108). For the deer mouse—second night, 72 (43–83); third night, 89 (75–100); fourth night, 102 (95–114). These figures represent means for the trapping periods in August, September, and October, when the population level was relatively stable; the figures in brackets are the extreme ranges observed in these three periods. In the calculation of p, the data for each period were treated separately; that is, animals marked in an earlier period were not considered as marked until their second capture in the given period. There is a consistent tendency for p to be too low after both the second and third nights of trapping. This is a strong indication that marked animals are more readily trapped than unmarked ones. After the fourth night, and subsequent nights, this tendency is obscured because most of the population has been marked. Tanaka (1951) also found that marked animals showed a greater probability of capture. Thus, under at least some trapping conditions, the basic requirements for the application of the Lincoln Index are not satisfied. Apparently, some individuals are more easily caught than others, and such individuals may be captured, marked, and re-captured, before the more wary individuals are taken for the first time.

For the analysis of snap-trap data, Hayne (1949*b*) suggests a graphical method in which the catch per night is plotted over the number of animals removed previously. If the number of animals captured during each night is proportional to the number present, a straight line will result, and the intercept of this line with the abscissa will give the total population. Moran (1951) presents a mathematical technique for the analysis of snap-trap data. Both methods, however,

are based on the assumption of equal probability of capture. That is, each animal in the population must react to the traps in the same way. The present data do not meet this requirement. It is known that different species of small mammals differ widely in their susceptibility to capture and that some species are not attracted to traps at all (Edwards, 1952). Perhaps it is also true that within certain species, different individuals react differently, either through "trap-shyness" or through the relative attractiveness of the bait. This leads to the disturbing possibility that some individuals at the lower extreme of the reaction scale continue to avoid capture, even when it is believed that all animals of a given species have been taken.

DISCUSSION

In quantitative synecology, where the object is to measure both insect and mammal populations in relation to forest type and silvicultural treatment, a method of trapping is required that permits the sampling of many habitats without great expenditure of time. The trapping in New Brunswick and the Gaspé in 1941 was an attempt to apply such a method, although its basic assumptions were tested inadequately or not at all. In fact, more recent work indicates that some of these assumptions are seriously open to question. The main purpose in presenting the 1941 data is to show the nature of the problem, to list for a number of forest habitats population figures that have some relative significance although their absolute values are questionable, and to point out the necessity for fundamental work.

A review of the literature since 1941 shows that the fundamental work necessary to the development of practical trapping methods has yet to be done. Recent papers fall into two groups. In the first group, the investigators have examined existing methods rather critically and pointed out various sources of error. Rarely, however, have they gone far enough to permit the evaluation of these errors, or to separate academic sources of error from those that will have a significant effect on results. Undoubtedly, any practical method will have sources of error, and the essential thing is to find their probable magnitude so that the insignificant ones can be disregarded and the more serious ones reduced by adjustments in field techniques or in analysis. In papers of the second group, the authors have apparently succumbed to the attraction offered by the "armchair" method of approach. Their examination of the mathematical theories of trapping are very useful, however, and will have a beneficial influence on future trapping experiments. Unfortunately, all mathematical solutions proposed to date are predicated on a constant probability of capture. This requirement has not been adequately tested but, in some instances at least, it is not satisfied by field data.

Of particular interest to the ecologist is the new method proposed by MacLulich (1951). By using a quadrat and a line of snap-traps in each habitat it is possible, through the application of certain simple relationships, to find the average range of movement. If further field trials reveal no serious difficulties, this approach will have many advantages over the one used in the present

study. Appropriate range figures will be obtained for each habitat as it is sampled, and the use of time-consuming live-traps, with their weaknesses as indicators of home range, will be obviated.

Other fundamental work remains to be done on the ability to trap the different species, as well as different individuals of the same species. There is no assurance as yet that trapping results adequately represent the total populations of certain species of rodents (Edwards, 1952). This applies also to the Soricidae, which are of particular interest to the entomologist. Experiments in which conventional traps are paired with other types, such as the sunken bucket trap, may provide new information on this factor. The rate of re-population of an area after snap-trapping also deserves further study. If quadrats are re-populated rather soon through outside population pressure, it may be quite feasible to use snap-traps year after year on permanent plots.

SUMMARY

Population data for small forest mammals were obtained on 21 plots in New Brunswick and the Gaspé in 1941. The object was to find whether the population density of small mammals, and hence their potential control value against forest insects, was related to forest type or silvicultural treatment.

Live-traps were used periodically on a central plot to determine home range and seasonal population trend. Snap-traps were used on all other plots. On the assumption that the live-traps and snap-traps were equal in efficiency, and that home ranges and seasonal trends were the same in different habitats, population per acre was calculated for all plots. These assumptions have not been adequately tested.

The red-backed vole was the predominant species in all coniferous and mixed-wood stands. The deer mouse, cinereous shrew, and short-tailed shrew were the other common species. The combined population of all species at the peak of the seasonal cycle varied from 0.6 per acre to 15.0 per acre. Population density was directly related to the amount of protective cover on the forest floor, the slash from partial cutting operations being particularly favourable.

The probability of capture appeared to be greater for marked than for unmarked animals. The data therefore did not satisfy the requirements of the Lincoln Index or of other analyses based on a constant probability of capture.

It is concluded that much work of a fundamental nature remains to be done before practical population techniques will be available to the ecologist.

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AN UNUSUAL ABUNDANCE OF SHORT-TAILED SHREWS, *BLARINA BREVICAUDA*

By C. David Fowle and R. Y. Edwards

Continuous fluctuation is one of the most outstanding characteristics of animal populations. Fluctuations in populations may be irregular or more or less periodic and may vary in amplitude from slight oscillations to extremely large increases or decreases. This paper describes an unusually large and sudden increase in numbers in a population of short-tailed shrews. During the summer of 1947 our observations in Algonquin Park, Ontario, showed that the short-tailed shrew, *Blarina brevicauda* (Say), had in less than a year become extremely abundant.

Many people have contributed assistance and data to this study. We wish to thank particularly the members of the staff of the Department of Lands and Forests' Wildlife Research Station, especially Messrs. R. Bateman, H. Cumming, R. McArthur, W. Morris, N. D. Patrick, D. Smith, and R. H. Stinson.

Methods.—Our observations were made in Algonquin Park at the Department of Lands and Forests' Wildlife Research Station. Data were collected in the course of a general study of small mammals which has been carried on each summer from 1945 to 1950, but we are concerned here chiefly with the data of 1947.

Several methods were employed to collect specimens of small mammals. Ordinary "snap-traps" or mouse traps were used mainly in lines but sometimes on plots. In addition, during the six summers over 200 animals of various species have been taken in so-called "water-traps" (Clarke, 1938; Prince, 1941). These are merely watertight containers such as a metal pail or wooden keg sunk into the ground and filled to a depth of two or three inches with water. Occasionally, small cans and short lengths of stove pipe were used. Animals falling into this type of trap are drowned. A few mammals were taken in pits and holes dug in the ground. Live-traps were employed chiefly on plots, but in 1947 and 1948 they were used fairly extensively in lines to collect live mammals for study. A few specimens were picked up dead or were otherwise obtained.

In 1945 and 1946 snap-trapping was concentrated in a smaller area than in the other four summers when a wide range of environments were trapped. In the first two years, work was confined largely to plots totalling about 23 acres in extent, but in the other years only a little of this type of trapping was undertaken, almost all animals being taken in the more productive lines. Additional data were available from the field notes of other members of the staff of the research station.

RESULTS

The extraordinary increase and decline in the porportion of *Blarina* that we observed during the six summers is shown in Table 1. It is noteworthy that in 1947 over 65 per cent of our catch from all sources and 72 per cent of the catch in snap-traps consisted of *Blarina*. The catch in live-traps was dominated by this species. In spite of variations in our trapping technique from year to year, we

TABLE 1.—*Percentage of Blarina in total catch of small mammals, 1945 to 1950*

Year	Total all species*	Number of *Blarina*	Percentage of *Blarina*
1945	244	8	3.2
1946	466	23	4.9
1947	931	611	65.6
1948	725	43	5.9
1949	1702	80	4.7
1950	415	3	0.7

* Genera: *Sorex* (3 species), *Microsorex, Blarina, Condylura, Tamias, Eutamias, Peromyscus, Synaptomys, Clethrionomys, Microtus, Zapus, Napaeozapus.*

believe that the increase noted in 1947 is far too large to be accounted for by these alone.

During the summer, traps were set at 42 stations, there being repeated trapping or prolonged trapping at some of them. At every station *Blarina* appeared in the catch. Moreover, *Blarina* dominated the catch in all but six stations and these six exceptions were somewhat unusual in that very few animals of any kind were taken.

As might be expected, the abundance of *Blarina* was not evident from trapping records only. Signs of their presence were everywhere in the forest. Tunnels in the duff on the forest floor were extremely common and widely distributed, and these, whenever set with traps, yielded *Blarina*. Early in June one of us walked about 660 feet through a mixed stand of white pine (*Pinus strobus* L.) and balsam fir (*Abies balsamea* (L.) Mill.) with a scattering of white birch (*Betula papyrifera* Marsh.) growing on a dry sand plain. Every 10 double paces a search was made for tunnels within a radius of three yards of where the observer stood. Although searching was restricted to half a minute at each station, workings were found at 11 of the 13 stops. The fact that this was a rather unproductive area in 1946 is indicated by the results of trapping on a 3.6 acre plot there in August of that year. At that time 1,800 snap-traps set for three nights took two *Blarina*. In contrast, two 0.1 acre plots, each set with 50 traps near the same site in May, 1947, yielded seven *Blarina* each in three nights. Another plot, 0.4 acres in extent in a different forest type and set with 49 traps in 1946, yielded one *Blarina* between July 30 and August 10. In 1947 this same plot produced 39 *Blarina* during the same period.

Ordinarily shrews of any kind were very rarely, if ever, observed in the field by members of the field staff, but in 1947 at least 25 reports dealing with live *Blarina* seen in the wild were received. In addition, they were occasionally seen crossing the highway during the day, and we have three records of animals seen swimming streams. These observations are not unusual in themselves but are cited merely to indicate the contrast with other years. Nine dead animals, probably killed by predators, were picked up between June 12 and July 19.

In addition, throughout the summer it was frequently possible to smell the musky odor of *Blarina* in the forest. The odor was not all-pervading, but it was

noted usually in the vicinity of stumps or decaying logs, which were undoubtedly inhabited by shrews. It was our impression that this condition was encountered most frequently in wet weather or early in the morning when the ground and vegetation were wet.

It is of interest also that *Blarina* occurred commonly in the foods of various animals. Near the end of June, Dr. J. M. Speirs, Ontario Fisheries Research Laboratory, collected between 300 and 400 owl pellets, probably of the barred owl, *Strix varia* (Barton), under a roost on a small island in Lake Opeongo, about eight miles from our station. Superficial examination revealed these to be composed mainly of *Blarina* remains. A detailed analysis of 50 of the pellets selected at random showed that every one contained the parts of from one to 11 *Blarina* and averaged about five each, while 18 of them contained remains from six or more *Blarina*. Some pellets were composed almost entirely of remains of *Blarina* but most of them contained a few fish bones, scales, and parts of insects.

During the summer, three fox stomachs were examined; one of these contained one *Blarina* and another, three. Fox scats were frequently found to contain remains of *Blarina*. Schueler (1951) reports that in the summer of 1947 he collected 400 scats of the red fox, *Vulpes fulva* (Desmarest), in the Central Adirondacks of New York. Analysis of these revealed that shrews (*Sorex* and *Blarina*) occurred more frequently than other items during the early summer to the end of July, and constituted an important element in the diet into September. This is quite unusual in view of the usually low occurrence of shrews in the diet of foxes (Hamilton, 1935; Hatfield, 1939; Seagears, 1945; Scott, 1947).

Reports were received from the Ontario Fisheries Research Laboratory regarding three lake trout, *Salvelinus namaycush* (Walbaum), in Lake Opeongo in the Park. These fish each had at least one *Blarina* in their stomachs and one contained three.

Reports we have received from six other trappers elsewhere in the Park and south and west of it all indicated high populations of *Blarina*, their catches averaging over 60 per cent *Blarina* (J. R. Dymond, M. Jackson, H. Morris, A. Cringan, R. Y. Edwards, and D. Smith). Mr. K. M. Mayall, of the Ontario Department of Planning and Development, reported in June that 50 (60%) out of the 82 small mammals caught in southeastern Ontario were short-tailed shrews. D. Smith of Toronto reports that in 1,142 trap-nights between June 30 and August 24 he took 68 (60%) *Blarina* out of a total of 102 small mammals caught near Port Stanfield, Ontario.

Schapiro (1950) records a high proportion of *Blarina* in small mammals around Syracuse, New York, in 1948. Forty-six per cent of 288 animals of six species were *Blarina*.

It is important that only three of the 296 female *Blarina* examined in Algonquin Park between the end of May and the 22nd of September, were pregnant. We have concluded from this that little reproduction took place after the spring breeding season and, further, that the population probably declined during the summer. The expected decline is indicated by records from three stations that were trapped twice during the summer. Second trappings, carried out at in-

TABLE 2.—*Catch of Blarina in snap-traps by ten-day periods showing "trapping effort" necessary to take one Blarina*

Period	Total catch all species	*Blarina*	% *Blarina*	Trap-nights per *Blarina*	Total trap-nights
May 28–June 6	47	39	83	9.2	360
June 7–16	81	70	86	8.9	625
June 17–26	19	17	90	26.4	450
June 27–July 6	36	30	83	15.0	450
July 7–16	63	48	76	26.5	1275
July 17–26	70	49	70	22.4	1100
July 27–Aug. 5	82	70	86	38.5	2700
Aug. 6–15	73	37	51	98.7	3650
Aug. 16–25	39	22	56	146.6	3225
Aug. 26–Sept. 4	26	19	73	81.5	1550
Sept. 5–14	19	5	26	90.0	450
Sept. 15–22	18	4	22	225.0	900
	573	410	72	41.1	16,835

tervals of 10, 47 and 60 days respectively, yielded fewer *Blarina* than the first trappings. One line, trapped during the second week of June and again 60 days later in the second week of August, yielded 20 *Blarina* in the first trapping and 11 in the second. Table 2 shows that in general the percentage of *Blarina* taken in snap-traps diminished during the summer and the trapping effort in terms of trap-nights necessary to catch an animal increased. This may be due in part to the increase in other species, which reduced the number of traps available to *Blarina*. Other indications of a decline in population include the observations that no live *Blarina* was seen in the forest after August 1 and no dead *Blarina* were picked up after July 19.

However, in spite of what might be regarded as a fairly drastic decline in numbers, *Blarina* were still unusually abundant in September if our trapping records are reliable indicators. In 1947 over 50 per cent of the animals collected by all methods in August and about 26 per cent of those collected in September were *Blarina*. This is a contrast to 1946 when four per cent of the animals taken in August were *Blarina*. In 1948 about six per cent of the animals collected in August were *Blarina* and three per cent of those taken in the first half of September were *Blarina*.

DISCUSSION

We may now turn to a consideration of the source of this large number of animals. An increase in the number of animals within an area may be brought about by immigration of animals foreign to the area or as a result of the reproduction of the resident population. Considering the wide area apparently involved in the present case, immigration can probably be excluded as a factor except as a local phenomenom.

If reproduction of resident animals produced the increase, then it must have been confined to the spring and early summer of 1947, to the fall of 1946, or

both. Since only three pregnant females were found in the 296 females examined, reproduction was not contributing much to the increase in population during the trapping period. This observation is substantiated by those of others (Seton, 1909: 1122–1124; Hamilton, 1929; Townsend, 1935; Pearson, 1944; Bateman and Smith, 1948), by the records of the Royal Ontario Museum of Zoology and Palaeontology, and from our own field notes for other years. In all, 40 records of pregnancies have been reviewed and found to be segregated in time as follows: March—3, April—8, May—5, June—14, July—7, August—1, September—2. Three-quarters of the records occur before the end of June. Unfortunately, we have little data for either the fall of 1946 or the early spring of 1947, but we can say that our trapping at the end of August, 1946, gave no indication of breeding nor do our data show that an exceptionally high over-wintering population was on hand for the spring breeding. Only four per cent of all the animals collected in August, 1946, were *Blarina*. Moreover, when our trapping began on May 22, *Blarina* were already abundant and must have become so between September 1, 1946 and May 22, 1947.

That the increase in population probably began in the spring of 1947 is also suggested by data supplied by Bateman and Smith (1948). They trapped at Lake Boshkung about 40 miles south of our station between March 27 and April 4, 1948. In 1633 trap-nights they took 80 small mammals of eight species including 17 *Blarina*. Three of the seven female *Blarina* taken were pregnant and three others had placental scars in their uteri. The testes in nine of the ten males were considerably larger than those in almost all the males that we took during the previous summer.

It seems most likely that the increase in the numbers of *Blarina* resulted from the reproduction beginning in March, 1947, and from exceptionally high survival of young. Since the mean litter size for the 40 records of pregnancies mentioned above was 5.7, it is clear that large increases in populations are possible if survival of adults and young is high. Almost a fourfold increase in population is possible at each reproduction if all adults and young survive. The factors contributing to possible high survival in the spring of 1947 are not known. The mean monthly temperatures for January to May, 1947, are slightly lower than the 20-year average which might have contributed to the persistence of the snow cover for longer than usual. The snowfall in the winter of 1946–47 was exceptionally heavy, being 50 inches in excess of the 20-year average of 90.1 inches. Since that winter, no similar heavy falls of snow have been recorded (Dept. of Transport, 1946, 1947, 1948).

SUMMARY

During the summer of 1947 short-tailed shrews, *Blarina brevicauda* (Say), were unusually abundant in Algonquin Park, Ontario. This species constituted 65 per cent of the small mammals trapped as compared to 5 per cent in the previous year. They were frequently observed or found dead and they occurred in unexpected abundance in the diets of some predators. Similar high populations were reported from southern Ontario and in New York State. The data from

Algonquin Park suggest that the sudden increase took place between September, 1946, and May 22, 1947.

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HOME RANGE OF *PEROMYSCUS MANICULATUS RUFINUS* IN A COLORADO PONDEROSA PINE COMMUNITY

By Olwen Williams

Ecological literature of the past decade or more has indicated the value of home range information with respect to life history studies, control problems, and the estimation of small mammal populations. Nevertheless, in 1949 a review of the literature revealed little or no information of this sort available for mice in northern Colorado. This fact led to an attempt to determine the home range of several species of mice near Boulder, Colorado, during the spring and summer of 1950. The undertaking included a study of the home range of the white-footed mouse, *Peromyscus maniculatus rufinus*, in an area at the northeast end of Pennsylvania Gulch, approximately one-fourth mile southwest of Sunset, Boulder County, Colorado. The results of the work in Pennsylvania Gulch are herein reported.

Suggestions stemming from home range studies in other parts of the country proved helpful in organizing the present investigation. These included the work of Blair (1940, 1941, 1942) and Burt (1940, 1943) in Michigan, Hamilton (1937) in New York, and Stickel (1949) in Texas, to mention only a few. The techniques used by these people were all fundamentally the same, namely, the live-trapping, marking, releasing, and the subsequent recapture of the animals studied. The data obtained in this manner were used in a variety of ways to give home range figures. That the methods used were subject to criticism was pointed out by Mohr (1947) and Hayne (1949). The latter suggested that in the usual procedure, wherein an area was covered by a grid of live-traps in which the animals studied were captured over and over again, traps set near the home site might interfere with an animal's normal activity and reveal a home range much smaller than it actually was. The technique adopted for the present study derived from this criticism.

A quadrat was set up on the south-facing slope of the lower end of Pennsylvania Gulch at an altitude of approximately 8000 feet. The greater part of the Gulch is characterized by rocks of the Idaho Springs Formation, and outcroppings of the typical gneisses and schists of this complex were numerous. Dykes of quartz-pegmatite intrusions occurred in the immediate vicinity of the quadrat. Soil formation in the area of the dykes was poor and the vegetation correspondingly scanty. A great deal of loose talus material and tailings from abandoned mine shafts and prospect holes covered the steep slope. Despite the scantiness of the vegetation, countless niches and crevices provided excellent cover for small mammals.

The plant community consisted of an open stand of ponderosa pine (*Pinus ponderosa* var. *scopulorum*) with an admixture of Rocky Mountain juniper (*Juniperus scopulorum*) and Douglas fir (*Pseudotsuga taxifolia*). The sparse ground cover included a number of shrubs, namely, New Jersey tea (*Ceanothus fendleri*), squaw currant (*Ribes cereum*), skunkbush (*Rhus trilobata*), mountain juniper (*Juniperus communis*), kinnikinnik (*Arctostaphylos uva-ursi*) and soap-

weed (*Yucca glauca*). The grass on the slope was primarily cheatgrass (*Bromus tectorum*). Over twenty species of forbs were counted on the slope during the course of the study. By the end of the trapping period the quadrat had been expanded down the slope into the stream bottom where the dense mesophytic vegetation contrasted sharply with that a few yards above on the rocky slope. In the stream bottom, ponderosa pine gave way to Engelmann spruce (*Picea engelmannii*), subalpine fir (*Abies lasiocarpa*), quaking aspen (*Populus tremuloides*), willow (*Salix* spp.), Rocky Mountain birch (*Betula fontinalis*), and alder (*Alnus tenuifolia*).

Field work in Pennsylvania Gulch began on July 1, 1950. Traps were operated on weekends only until August 19. On the first night twelve traps were set in a line across the slope at measured intervals of sixty feet. This rather large interval was chosen to keep disturbance of the quadrat at a minimum; nevertheless, conspicuous paths were worn along the traplines over a period of a few weeks. The initial line was quickly expanded as individual animals were caught and marked by toe-clipping. Once an animal appeared in a trap, that trap was put out of operation. This procedure continued until all the points of capture of an animal lay within a ring of traps in which the animal did not appear, even after a prolonged period of trapping. The outlying points of capture were then used to designate the limits of the animal's home range.

The light traps used in this investigation were fashioned from tin cans and ordinary mouse traps with a piece of hardware cloth fastened to the guillotine. The traps were lined with a layer of asbestos paper to cut down radiation of heat and to keep the mice from contact with the cold metal surfaces. However, each time a new trap was used the mouse caught in it carefully peeled the paper from the walls and used it as nesting material. To further reduce the danger from the low temperatures characteristic of even summer nights at high altitudes in Colorado, a small amount of corn was placed in each trap in addition to the bait which was a mixture of oatmeal, raisins, and bacon.

Some difficulty was experienced from heat as well as from cold. Since the vegetation was very sparse, it was not always possible to set traps where they could be shielded from the hot rays of the early morning sun which shone directly on the steep south-facing slope. The hours from eight to ten in the morning constituted the hottest part of the day, since a cloud cover usually formed during the late morning hours. Because of this, the traps were inspected and the mice were released between 5:30 and 7:30 each morning. The traps were left unset during the day.

Thirty-three individuals were captured and marked in Pennsylvania Gulch. Of these, twenty-one animals were taken three or more times and their home ranges were calculated from the data thus obtained. The average home ranges for these mice were as follows: mature males 0.52 acres, mature females 0.36 acres, immature males 0.625 acres, immature females 0.31 acres. Based on capture at four or more points the average home range figures change somewhat and read as follows: mature males 0.81 acres, mature females 0.625 acres, immature males 0.625 acres, immature females 0.328 acres.

In addition to providing some indication of the size of home range for this particular subspecies of *Peromyscus*, this study served also to test, in a limited way, Hayne's suggestion that the more conventional method of obtaining home range information gave results that showed the range much smaller than it actually was. Blair (1940), using the conventional method, obtained figures for *Peromyscus maniculatus bairdii* that do not differ very greatly from the results obtained in the present investigation. On the other hand, earlier in 1950, in another quadrat, the writer captured one mouse eight times in the same trap on eight successive nights. This mouse did not appear elsewhere until that trap was closed out. By closing additional traps as further recaptures occurred the same animal was shown to have a range of 0.57 acres before the expanding ring of traps lay outside of his apparent range. Possibly there is a good deal of individual variation in this matter. Trap interference, as Hayne (*op. cit.*) termed it, may be a more important factor in the case of trap-addicted individuals than in the case of others. That such animals exist is supported by the literature.

It was noted that the home ranges in this study overlapped broadly for both males and females. Usually no more than three ranges overlapped at any one point but in some places as many as four did so. The overlapping of ranges in itself induced a type of trap interference in view of the trapping method used.

At the end of the trapping period the quadrat was snap-trapped to see if any difference might exist between snap-trapping and live trapping with respect to the number of individuals and the number of species captured. Two lines of snap-traps were set up, one traversing the broken rocky slope and one paralleling the stream at the bottom of the slope. These traps were operated for one night only. Sixteen *Peromyscus* were caught in the traps on the slope. One animal was alive and escaped when the trap was released. Of the remaining fifteen mice only five showed the multilation marks that had been used during the study. The others were unmarked and had not been trapped before. In the stream bottom eleven animals were trapped; none had been captured before. Seven of these animals were identified as *Peromyscus maniculatus*; one animal was a shrew, *Sorex obscurus obscurus*; one was a red-backed mouse, *Clethrionomys gapperi galei*; and two were jumping mice, *Zapus princeps princeps*. Only one white-footed mouse and one jumping mouse had been caught in the stream bottom during the live-trapping period. Apparently this form of trapping had failed to capture all of the animals resident in the quadrat.

Summary.—A study of the home range of *Peromyscus maniculatus rufinus* captured by live-trapping in a ponderosa pine forest in north central Colorado provided home range estimates for twenty-one animals. Based on capture at three or more points, mature males had ranges of 0.52 acres, mature females of 0.36 acres, immature males of 0.625 acres, and immature females of 0.31 acres. Although the study was made during the breeding season the ranges of both males and females overlapped broadly, possibly indicating little intraspecific intolerance in this subspecies.

Acknowledgments.—In presenting this material I wish to express my appreciation to Dr. Gordon Alexander, Department of Biology, University of

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A TECHNIQUE FOR INVESTIGATING THE DISTANCE PARAMETER OF HOME RANGE

BY JOHN B. CALHOUN

Hayne (Jour. Mamm., 30: 1–18, 1949) has stated that there must be a decreasing probability of observing an animal per unit of area at increasing distances from the mean coordinate point of the places where it was observed. This point may be defined as the center of the home range. Calhoun, Casby, and Brant (manuscript) have presented a mathematical formulation of this phenomenon. However, when the probability is considered merely from the viewpoint of the radial distance from the center of the home range, there is an increasing probability of observing the animal up to some particular radius, beyond which the probability again decreases (Dice and Clark, Contr. Lab. Vert. Biol. Univ. Michigan, No. 62: 1–15, 1952). This latter is so because as the probability per unit of area decreases with increases in radial distance from the center of the home range, bands of equal width w increase in area by a constant amount, $2\pi w^2$, with each increase of w in radial distance.

It was desired to investigate those problems of home range related to the decreasing probability of observing an animal at increasing distances from the center of home range. The purposes of this paper will be to describe techniques for accomplishing this under laboratory conditions, and to discuss relevant problems of procedure.

THE EXPERIMENTAL APPARATUS

Three criteria must be met if only those conditions relating to the movement of animals with reference to distance are to be studied: (1) The space available to the animal must be essentially linear in nature. That is, it should be relatively long with reference to a constant narrow width. (2) One end of the space should form a locus of orientation, from which the frequency of an animal being or behaving may be related to distance. (3) The length of the space should be actually or psychologically long enough to produce a low probability of the animal arriving toward that end of the space opposite to the locus of orientation.

The general specifications satisfying the first criterion was that the space should be a long alley having a width slightly greater than the body length of the experimental animal. At least the source for satisfying one basic need such as hunger, thirst or shelter should be concentrated at one end of the alley in order to form a locus of orientation. This locus may be considered as analogous to the center of the home range. From what is known of the distances which mammals travel from the center of their home range, it was quite apparent that meeting the third criterion would be difficult, at least if the alley were to be short enough to be encompassed within a typical laboratory room. Dr. Eckard Hess of the University of Chicago suggested a means of increasing the length of the alley psychologically. His suggestion was that, if nocturnal animals were used as experimental subjects, a light placed at the end of the alley opposite to the locus of orientation might serve to inhibit the outward movements.

Laboratory breeds of the Norway rat, *Rattus norvegicus* were selected as experimental subjects. The apparatus consisted of an alley 8 inches wide, 12 inches high, and 14 feet long made of plywood. The top was covered with movable screen partitions. A U shaped hood of plywood 14 inches wide, with flanges hanging 3 inches below the top of the alley was supported over the top of the alley in order to decrease the amount of extraneous light from outside the alley and also to provide ventilation. At one end of the alley a compartment 6 x 8 inches formed the locus of orientation in which food, water or both were always available. A three-inch diameter opening faced down the alley from this compartment. Beginning at this door there were twelve treadles, each $7\frac{3}{4}''$ x $11\frac{3}{4}''$. A 50-gram pressure on the distal end of a treadle was sufficient to depress it and close a microswitch which, in turn, activated a counter. A separate counter was connected to each treadle. The light socket was placed at a level with the top of the alley and 14 inches distal to the end of the twelfth treadle. Seven inches in front of the light a flange was extended across the top of the alley forming an aperture 3.5 x 8 inches for light to pass through. This flange prevented the subjects from viewing the illuminated lamps of 60 watt size or smaller, until they had reached the twelfth treadle. Both the 100 and 200 watt lamps used were large enough to be partially visible even at the locus of orientation, and the closer the rat approached the more of the bulb could be seen. The entire light compartment was painted white; whereas, the alley was a dull black.

The brightness of the light visible through this 3.5 x 8 inch opening was: 7.8 foot candles with a 25 watt lamp; 26.6 with a 60 watt lamp; 70.0 with a 100 watt

TABLE 1.—*Sequence and experimental conditions relating to rats run in the alley*

Rat number	Water		Wattage of lamp at end of alley on trial*		
	Home cage	Each position along alley	A	B	C
000,20		X	None (1)	60 (2)	100 (3)
			5806	3668	3116
000,19	X		None (4)	60 (5)	100 (6)
			5113	1901	1800
000,21	X		100 (7)	60 (8)	None (9)
			1729	2467	4804
000,22		X	100 (10)	60 (11)	None (12)
			3848	5714	3086
000,29	X		25 (13)	200 (14)	—
			9700	428	
000,28	X		200 (15)	25 (16)	—
			1138	2194	

* The numbers in parentheses refer to the chronological order of the trials, while the numbers below the wattage of the lamp refer to the total treadle count for each 7-day trial.

lamp, and 2,033 foot candles with the 200 watt lamp. All measurements were made with a Macbeth Illuminometer four inches from the distal end of treadle number six.

SUBJECTS AND METHODS

Male Fischer strain rats which had been inbred for 56 generations were the subjects. This is an albino strain. Table 1 shows the order and conditions of the pilot trials. Males 19 to 22 were sibs born February 6, 1953. Males 28 and 29 were sibs born February 16, 1953. Each animal was run for seven consecutive days per trial. The two or three trials for each rat were run consecutively. For those trials during which water was placed in the alleys it was available in graduated Richter water fountains attached to one side of the alley above the distal end of each treadle. When no light was used during a trial, a barrier was placed across the aperture to the light compartment. Although this prevented the rat from entering the light compartment, it still could stand on the seven inch platform between the last treadle and the barrier.

RESULTS

For each seven-day trial the percentage of the total treadle count was calculated for each of the twelve treadle positions. By selecting the maximum and minimum percentages for each position the gross effects of light in altering the outward movements from the locus of orientation are apparent (Fig. 1).

There were only four trials (4, 7, 13, 15) that represented a rat's initial experience in an unstructured alley (Fig. 1). They depict the influence of light intensity upon exploratory behavior. When no light was present, there was a very slow decrease in the frequency of visiting more distant points. In fact, there was an increase in the visitations at the end of the alley. As the intensity of the source of

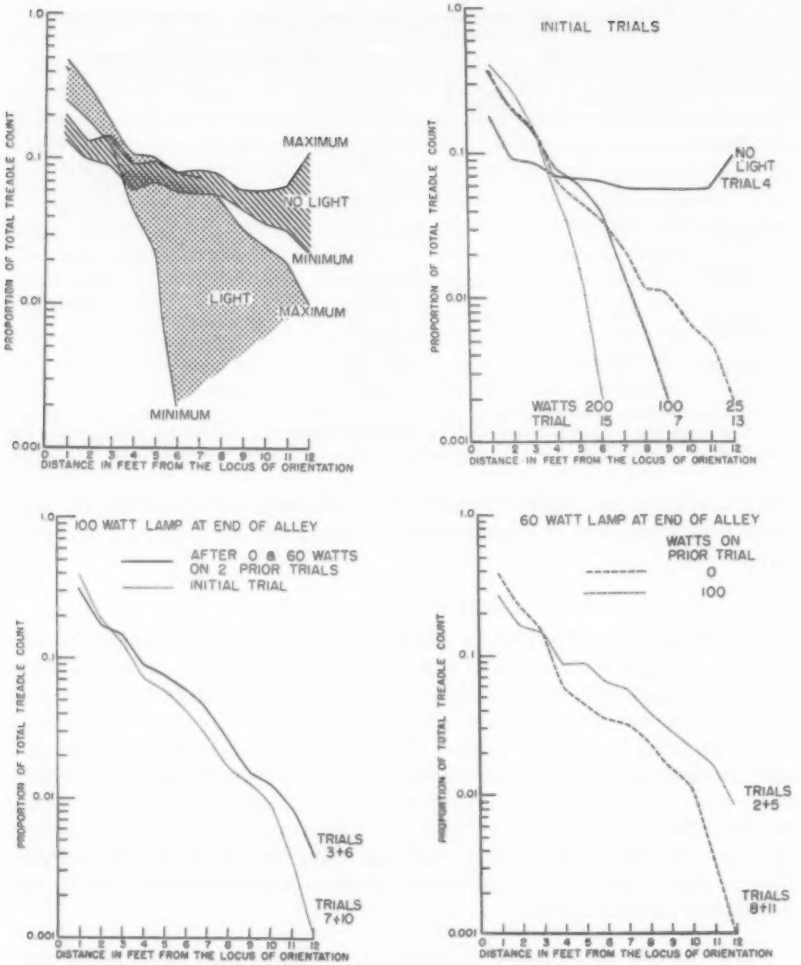

FIG. 1.—UPPER LEFT: Exploration in an alley in darkness versus that when lights of 7.8 to 2,033.5 foot candles occurred at the terminal end.

UPPER RIGHT: Exploration in the alley during initial trials.

LOWER LEFT: The increase in outward exploration with a 100 watt lamp at the end of the alley when there had been prior experience of exploration exposed to a less inhibiting light intensity.

LOWER RIGHT: The effect of prior experience on the pattern of outward exploration. With a 60 watt light at the end of the alley there was more outward exploration if the prior trial was without light than there was when the prior trial was with the more inhibiting 100 watt lamp.

light at the end of the alley increased, there was a progressive diminution in the frequency of visiting positions approaching the light source.

Since each rat during consecutive trials was exposed to different light intensities, it was possible to determine the effect of prior experience in the alley upon the amount of exploratory behavior by the rat. Exploration toward a 100 watt lamp exhibited a much greater inhibition when the trial was an initial experience than when it had been preceded by 0 and 60 watts during the two prior trials. However, one might argue that the greater amount of distal exploration following prior trials at lower light intensities was a consequence of greater familiarity with the situation. The data on exploration in the alley with a 60 watt lamp at one end is uncomplicated by differences in amount of prior experience. Each trial at 60 watts was preceded by a one week's trial at either no light or 100 watts. Actually there was no appreciable difference between the exploration during trials 8 and 11 with a 60 watt light source than there had been during the preceding trials 7 and 10 with a 100 watt light source. However, when the rats had prior experience in the alley with no inhibiting light, there was a marked increase in outward exploration in contrast to that at 60 watts when there had been prior experience at a higher light intensity.

So far we have dealt with the relative amounts of activity along the alley. It is also apparent that the greater the light intensity at the end of the alley the less is the activity in the alley. (Table 2, data a and b). Probably because of differences in age and past history the sibs used in the trials with 0, 60, and 100 watt lamps cannot be directly compared with the sibs exposed to 25 and 200 watt lamps. Data marked d and f in Table 2 indicate that the intensity of activity, at a given condition of light intensity at the end of the alley, is reduced over what it was in initial trials, provided there was a higher intensity of light during the preceding trial. Likewise, activity is increased under exposure to a 200 watt lamp following a prior trial at 25 watts in comparison to what it was on an initial trial at 200 watts. The e data at 100 watts is inconclusive. Direct comparison cannot be made of the intensity of activity at 60 watts (the c data) with the d and f data

TABLE 2.—*Average treadle count per week*

	Watts of lamp at end of alley				
	0	60	100	25	200
All trials	4902	a 3438	2623	5419 b	1311
After 0 f.c.		c 2785			
After 100 watt		4091			
After 60 watt	d 3945		e 2458		
Initial	5460		2789	9700 f	428
Secondary				1138	2194

at 0, 25, and 200 watts, because no initial trials were run at 60 watts. What this c data at 60 watts appears to indicate is that the inhibitory effect of a given light intensity is greater if the rat has had the opportunity of experiencing a less inhibitory condition of light on the preceding trial.

During five of the six trials in which water was available at each treadle position in the alley there was a greater amount of activity in the alley than during the corresponding trial with water only in the home cage. No significance can be attributed to the presence of these goals in attracting the rats out into the alley. There was a serious fault in the experimental design. This was that during these trials water should also have been available in the home cage. Thus, the rats were forced to go out into the alley to get water. Had water also been in the home cage and had there still been an increase in the amount of activity in the alley, then one might conclude that the increased activity in the alley resulted from the additional objects with which the rat could respond. Other than a considerable increase in activity at the first treadle when water was present in the alley there was no real difference in the percentage of activity at the various positions along the alley. Even though 21 per cent of the total treadle count during trials when light was present at the end of the alley (trials 2, 3, 11 and 12) occurred at or beyond treadle 5, no appreciable water was drunk from treadles 6 to 12. The nearly 800 cc. of water consumed during these trials was distributed as follows: Treadle 1, .695; treadle 2, .245; treadle 3, .046; treadle 4, .015. Feces outside the home cage had a similar distribution of .789, .175, .031 and .005 over the first four treadles. These data indicate that drinking and defecation are both closely associated with the place where food was consumed.

DISCUSSION

The data in this paper amply demonstrate that, with a photophobic nocturnal animal such as the rat, the actual distance of an alley may be psychologically increased by the simple procedure of placing a source of light at one end of the alley. This technique permits the analysis of the distance parameter of home range. Sex, age, prior experience, heredity, motivation, and the presence of physical structures or goals are the main variables which might be investigated with such apparatus. However, since the main intent of this paper was to discuss technique, it may be helpful if some of the shortcomings of the present apparatus are mentioned.

The method of presenting the sources of light at the end of the alley was not completely satisfactory. A method permitting greater control over the light source would be one in which the light is spread over a ground glass plate by a lens, and in which intensity might be varied by a diaphragm between the light and the lens. Another unknown variable is the size of the light source over the ground glass plate.

Only the number of times that a rat came to each treadle position was recorded by the present apparatus. Thus, it was only possible to determine the probability of a rat arriving at a given distance from the center of orientation. Of equal, if not greater, importance is the amount of time spent at each distance. A clock or time counter activated by each treadle would satisfy this objective. An improved

treadle design over the present one is required since this one will only activate the microswitch when the rat is on the distal end of the treadle.

Despite the crudeness of the light source it is quite apparent that a dim light is sufficiently inhibitory to produce the psychological increase in distance required for studying the distance parameter of home range in the laboratory. A brightness of 5 to 30 foot candles at the light source is adequate. Within this range, at least, there is an exponential decrease in the frequency of being at different distances from a center of orientation. (See the curve for treadle count at 25 watts in Figure 1 and for trials 2 plus 5 at 60 watts in the figure.) This regularity of the data, however, does not in itself permit any insight into the nature of the psychological increase of distance produced by a light at the end of the alley. Such an insight may only be gained in comparison with records in an alley without a light at the end, which is sufficiently long to be little affected by the terminal end of the alley serving as a barrier as it did in the short alley used in this study.

However, I have two sets of unpublished data gathered on free ranging wild Norway rats which indicate that there is an exponential decrease in frequency with distance. The two items measured were the lengths of tunnel segments constructed by rats and the arrivals at different distances along a fence from a point of orientation. If, as is indicated, there is an exponential decrease with distance of frequency of arriving at points from a locus of orientation regardless of whether or not an inhibitory light is used; then the effect of light at the end of the alley is to increase each unit of distance by a constant amount. Had the size of the visual image of the light source impinging upon the retina been an important influencing factor one would have anticipated a more rapid decrease in frequency than expressed by an exponential curve. Such a decrease was actually obtained during trials 7 and 15 at 100 and 200 watts (Fig. 1). This was probably due to the fact that these large bulbs partially protruded below the flange and so the closer the rats came to the end of the alley the brighter the light source became, since more of the bulb was visible.

There is every reason to suspect that the technique presented here for psychologically increasing distance might be equally useful for the experimental study of home range in two dimensional space. By placing a series of lamps covered by a strip of ground glass at the base of the fence surrounding a circular pen, the space demanded for the expression of home range could be reduced sufficiently to make it amenable to experimental analysis.

Data were presented which showed that prior experience in the alley under one set of conditions influenced behavior during a subsequent trial under another set of conditions. Our interest here is not so much in the specific nature of this influence, but rather that it exists. From the viewpoint of technique these observations demand that caution be exercised in utilizing the same experimental subject during trials in the alley where the structured situation differs, unless the objective is to investigate the influence of prior experience.

SUMMARY

A technique is described for psychologically increasing distance in a nocturnal photophobic rodent such as the Norway rat. This technique consists of placing a

light at the end of an enclosed alley opposite to that which serves as a locus of orientation. The light apparently serves to psychologically increase each unit of distance by a constant amount. Thus, it is possible to investigate behavior with respect to distance in the confines of a 14 foot alley that otherwise would have required an alley several times this length.

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OBSERVATIONS ON THE LIFE HISTORY OF THE NORTHERN PINE MOUSE

By Allen H. Benton

Throughout much of the eastern United States, the pine mouse, *Pitymys pinetorum*, is a mammal of major importance in orchards, gardens, and other crops, and is of special interest because of its unique habits. Although its harmful activities have been recognized for more than a century, no comprehensive life history study has been published. The present study was undertaken at the suggestion of Dr. W. J. Hamilton Jr.

Most of the field work was conducted in the Elmendorf Orchard at Kingston, Ulster County, New York. Pine mice have been a serious problem there for many years, and the population was sufficient to supply adequate specimens for study. Additional specimens were collected in central New York and southern New Jersey, and James Chamberlain donated five specimens from Massachusetts. Field studies were conducted about Ithaca, N. Y., in the summer of 1950. In 1951, studies were made at Kingston, and continued until the completion of the project. More than 100 specimens were taken in this orchard. Thirty individuals were kept in captivity for study during this period.

In the progress of the work, I have been advised and assisted by Dr. W. J. Hamilton Jr. of Cornell University. For identification of material I am indebted to Dr. C. F. W. Muesebeck and cooperating specialists of the Department of Agriculture, Bureau of Insect Identification, Washington, D. C.; to George Ball, James N. Layne, Theodore Cohn and Dr. B. V. Travis of Cornell University; to Dr. Harley VanCleave of the University of Illinois; and to John Wilcox of the New York State Museum, Albany, N. Y.

Special thanks are due to Mr. Ray Elmendorf of Kingston, who gave me free access to his orchard and cooperated fully in every way to make the project proceed smoothly.

Description.—The northern pine mouse *Pitymys pinetorum scalopsoides* (Audubon and Bachman), is one of the larger forms of the species. Twenty-five adults from New York and New Jersey, in my collection, average: total length, 121.0 mm. (113–132); tail length, 21.3 mm. (16–24.5); hind foot, 16.6 mm. (14.5–18); weight, 25.6 grams (22–37). No pregnant females were included in the figures for weight.

Externally the pine mouse is well adapted for a subterranean habitat. The body is cylindrical and slender, the eyes and ears small. The facial vibrissae are well

developed. The hair is similar in form and texture to that of *Blarina* or *Parascalops*. It is finer than that of other voles, the basal portion being soft, flexible and wavy.

The skin of *Pitymys* is loose, thin and delicate. It is often torn during fighting, and may be torn accidentally on some sharp object, or during handling. These tears heal rapidly and apparently have little effect on the health of the animal.

The mouth is small, and the upper lips are closely appressed beneath the upper incisors. The lower lips bear an inwardly projecting fringe of hairs that lie along the dorsal surface of the tongue. A patch of hair on the internal surface of each cheek, behind the corner of the mouth, may further serve to protect the mouth cavity from the entrance of foreign matter.

Buffy specimens occasionally occur in this species, but albinism has not been reported. White spotting, however, is relatively common. White commonly occurs at the tip of the tail, and in some captive mice it has appeared in hairs on scar tissue.

Signs of presence.—The burrows of pine mice do not differ markedly from those of other small fossorial mammals of similar habitat. Indeed, these little animals use each other's burrows in what is described by Rhoads (1903) as "a most democratic fashion." In woodlands where the burrows are used by various small mammals, the only sure way of establishing the presence of pine mice is by trapping them. Where pine mice are common and other small mammals are absent or rare, their burrows may run about under the leaf mold and in and out of the ground in characteristic fashion. Their earth piles are similar to those of *Condylura cristata*, although the latter usually lives in wetter locations. The presence of cut grasses and stems in burrows is characteristic of several voles. The diameter and shape of pine mouse burrows is so variable that these criteria are of little value.

In open sandy fields or woodlands, pine mouse burrows may show characteristic profiles, with frequent openings to the surface and dirt piles which surmount several fresh tunnels below the surface. Under such circumstances, it is possible to be fairly certain that the burrows were made by pine mice. They may, however, be occupied by other species, notably *Blarina*.

In orchards, the subterranean burrows of the pine mice often run along the roots of apple trees, which may be gradually stripped of their bark and cambium. Around the trunks the network of burrows becomes more complex, and one or more burrows usually lead around the trunk below the surface. The tree may be sometimes completely girdled to a foot or more below the surface.

Orchard nests are often placed near the trunk of a tree, at a depth of several inches to a foot. In woodlands and fields, nests are often found under stumps, logs, or pieces of debris, often at the surface of the ground or but slightly below. The nest is made of available plant stems, leaves, or rootlets. Most of the orchard nests were of this type. Schmidt (1931) found nests made of maple leaves. Mice in the orchard studied often took cotton from live-traps and incorporated it into their nests. Several large runways usually led away from the nest cavity.

At intervals along the burrows, enlargements may be found that contain

stored rootstocks, stems, tubers or other food (Hamilton, 1938). Such storehouses were seldom found in the orchard studied, where an abundant supply of winter food, in the form of roots and bark, was always available. In the season when apples were lying about on the ground, their hollowed shells on the surface testified to the activity of these animals. If these signs are not noted, the first indication of the presence of pine mice may be a yellowing of the foliage on infested trees. *Pitymys* does not hesitate to attack even the largest trees, for the roots, unlike the trunk, are not protected by rough unpalatable bark.

Habitat.—Few small mammals occur in so wide a range of habitats as does this species. Though most common in relatively dry areas, it has been taken in swamps and marshes (Hamilton, 1938; Dice, 1925; Komarek and Komarek, 1938). Soil type appears to be more important than cover type in determining its distribution. Jameson (1949) suggested that in central New York "the physical nature of the humus is one of the most important environmental factors affecting this rodent." Hanson (1944) found them only in forests bearing a heavy carpet of litter and leaf mold. Light soils or deep humus seem to be a primary factor in the habitat of this species, unless burrows of other small mammals in heavier soils are utilized.

The fact that this species spends much time below the surface of the ground may tend to minimize the importance of cover in its habitat. However, pine mice run about freely on the surface at times, and are often taken outside of any visible runway.

Relationships to climate.—Like other fossorial animals, the pine mouse is to some extent independent of minor climatic fluctuations. Major climatic events may be important. Stickel (1948) recorded fourteen pine mice on floating debris during a midsummer flood in Maryland. Blair (1939) found an area in Oklahoma, usually well populated with pine mice, completely free of them for an entire year after a flood.

Pine mice are sensitive to high temperature, as evidenced by their restricted activity during hot summer days. They are active the year around, and in captivity do not appear to be disturbed by low temperatures if sufficient nesting material is supplied. Extremes of either hot or cold weather are likely to limit activity of these mice, in nature, to the deeper burrows. This was observed in the results of trapping throughout the year.

Time of Activity.—Pearson (1947) studied the metabolic rate of the pine mouse as determined by oxygen consumption during a 24-hour period. He found that this mouse showed a night-day ratio of 1.02:1, and interpreted this as indicating a slight tendency toward nocturnality. Werner, (1951) using an activity cage, found activity largely confined to the hours of twilight and darkness. In neither case, apparently, was the temperature or humidity controlled. These factors may have had an effect on the time of activity. Both workers indicated a regular cycle of short periods of about an hour of activity and an hour of rest.

Trapping data on 104 individuals indicate a slightly greater amount of activity at night than during the day. In considering trapping data, it must be remembered that activity at deeper levels may go on without resulting in the cap-

ture of the mice. Such data are thus subject to error. There is some evidence that above-ground daytime activity varies with the season, but further data are needed to establish seasonal trends.

Home-range.—Burt (1940) found the average home range of 17 pine mice in an oak-hickory woodland to be 38 yards in diameter, about one-quarter of an acre. These ranges varied from 15 yards in diameter to 93 yards. Their relatively sedentary habit was illustrated by two specimens taken a year after marking, 63 and 48 yards respectively from the point of marking.

During April to July, 1952, 27 pine mice were trapped, marked and released in a half-acre area, at Kingston, N. Y. Thirteen individuals that were taken three or more times had an average home range, based on these captures, of 21 yards in diameter. No individual was taken at points more than 50 yards apart. Several individuals were taken only about a single tree. If they were in reality restricted to that tree, their home range would have a diameter of about ten yards. Pine mice have a vertical as well as a horizontal range, for their burrows may extend for several feet below the surface. Where this vertical range includes an abundant food supply, as is often the case in orchards, a smaller horizontal home range may be required.

Fifteen mice were released at points from 60 to 150 feet from their point of capture, and in every case outside the home range as determined by retrapping. Eleven of these were recaptured in the study area, six of them at the tree where they were first taken. One returned a distance of 150 feet within 24 hours; another covered 100 feet and was recaptured at the home tree within 12 hours.

Populations of these mice are very local and highly variable. In October, 1951, eleven mice were taken about a single tree. Five or more have been taken around one tree on numerous occasions. These are usually two adults and several juveniles or subadults, indicating that they may be a pair and their young. The population is usually not evenly distributed throughout the habitat. In the 40-acre Elmendorf orchard, there were only four areas, of a half-acre to an acre each, which supported sizeable populations of these voles during the study period. They do not remain in the same area year after year, but move about slowly, and gradually occupy new areas. Emigration probably occurs during late summer and fall, as mice mature and overcrowd the home area. In 1952, the first appearance of mice in areas unoccupied in the spring was in early July.

At times these voles may show marked population fluctuations. The owner of the orchard informed me that about 1942 a trapper took about 500 mice from a two-acre area. Hamilton (1938) recorded a similar situation at Croton Falls, New York. These population fluctuations are said by Hamilton (1938) and Linduska (1942) to correspond roughly in time with those of *Microtus*.

Reproduction.—Most authors have credited the pine mouse with year-around reproduction. These statements are based on the collection of young or of pregnant females during January and February. Glass (1949) found pregnant females of *P. p. nemoralis* in Oklahoma during early January. Linsdale (1928) trapped pregnant females of this subspecies in Missouri during late February. Rhoads (1903) reported taking nursing and gravid females at all seasons. Hamilton (1938)

found that captive mice bred from early April to late September, but recorded other instances of breeding occurring from March to late October.

Examination of more than one hundred specimens from my own collection and specimens in the Cornell University collection indicates a well-marked breeding season, extending from January to October. A captive female had five young on February 11, indicating that she was bred about January 20th. Half-grown mice were taken in the wild in late March, while captive males were in breeding condition during January and February.

During March and April, breeding reaches a peak. All adult males taken at this time were in breeding condition, and many nursing or gravid females were taken. Breeding continues until early October, and a single female may produce several litters during this period. Cessation of breeding occurs in late September and October. The male sex glands and organs shrink. The testes become flaccid and reduced in size, not exceeding three or four millimeters in length. Gravid females have been recorded in early October, and on October 21, 1951, four young about ten or twelve days old were taken. Of 47 individuals taken during late October and November, none showed any evidence of being in breeding condition.

In December, the males begin to approach breeding condition. One individual that died in late December had spermatozoa in the cauda epididymis. There is no direct evidence of breeding in New York before January.

It is possible that these animals may breed throughout the year on some occasions, as has been shown for *Microtus* (Hamilton, 1937). Under normal circumstances, however, there is a lapse of about three months in reproductive activity during late autumn and early winter.

Pine mice characteristically have litters of two to four, although as many as eight embryos have been found (Roberts and Early, 1952). Occasional specimens are taken that bear a single embryo.

Mating behavior.—The few observations of mating behavior in captivity indicate that the female is the aggressor. She initiates the act by seizing the male by the flank or hip with her teeth. At times she may drag the male backward. Periodically she releases her hold and rubs her nose over his flanks and anal area. She may then advance in front of the male, dragging her genital area along the ground. The only observed copulation occurred after about one-half hour of these preliminaries. Copulation lasted only a few seconds, and was not repeated during the period of observation. It did not result in conception, so it is possible that it does not represent normal copulation.

The vaginal plug, formed after copulation, is a yellowish viscous mass occupying most of the vagina, but usually not visible externally. It probably persists for several days since it was found in one female two days after copulation. The vulva normally remains open for several days after mating, and may open some time before parturition. One female with three 20-mm. embryos had the membrane perforated.

The gestation period of the pine mouse has not been definitely established, but it is probably near the twenty-one days determined for *Microtus*.

Growth and Development.—Hamilton (1938) described the development of several litters of pine mice produced by captive females. In general that account agrees with the results of this study. The young at birth are essentially hairless, except for a sprinkling of fuzzy hairs on the dorsal surface, and well developed mystacial bristles. With the short blunt claws of the forelimbs, the young are able to pull themselves about before they are a day old. They emit low squeaks and sucking noises when disturbed.

Hair appears on the fifth or sixth day, and the incisors erupt at about the same time. The ear pinnae unfold at eight days; the eyes open at nine to twelve days. By two weeks of age the mice are moving about freely. Several individuals of approximately this age were taken in the field, indicating that they leave the nest and wander about at this time. Weaning generally occurs during the third week.

Molt.—During the third week of life the fuzzy juvenile pelage is lost and immature pelage is attained. Soon thereafter adult pelage begins to appear around the sides and forelimbs. The immature to adult molt does not always follow the same pattern. In most observed animals it began on the sides near the forelimbs and proceeded forward and upward over the shoulders and head. Simultaneously it proceeded backward along the sides, then gradually backward along the back ending on the rump. Molt on the ventral surface follows closely that of the sides. In some individuals the molt proceeds forward, ending on the head. Adult pelage may be reached at seven to ten weeks, or may require longer if the animal is in poor health or perhaps for other undetermined reasons.

Molts of the adults occur in late fall and early winter, in early spring, and throughout the summer.

Food.—Field observations and stomach analyses show that the pine mouse utilizes a wide variety of bulbs, tubers, roots, seeds, fruits, bark, and leaves, and to a lesser extent animal matter. This may account both for its wide ecological distribution and its importance as a pest, for it will adapt readily to an abundant food supply of cultivated crops. Orchard pine mice appear to subsist largely on grass roots and stems during the summer, fruit and seeds during the fall, and bark, roots and possibly some stored food during the winter. Opportunism in taking food is indicated by the observations of Gifford and Whitebread (1951) of individuals that had the abdominal wall stained with color from pokeberries in the digestive tract, and of others that had eaten wild onions so freely that the flesh smelled strongly of onion. Sim (1934) offered the larvae of Japanese beetles to pine mice, and found that they were always accepted.

Odum (1944) tested the water intake of a captive pine mouse and found that it consumed 5.5 cc. of water per day. In nature they are not dependent on water to any great degree, and in captivity will thrive for extended periods without water if sufficient succulent food is supplied.

Individual characteristics.—Most pine mice are relatively placid, and some can be handled freely from the moment of taking. Others are violent and never submit willingly to handling. Their reaction to visual stimuli is not marked, but loud sounds will usually elicit an instant response in the form of a defensive or

hiding reaction. Their reaction to tactile stimuli is more striking, taking the form of a sudden leap or dash for cover.

Positive thigmotropism is marked in this species. Lacking cover, they will press as closely as possible against any available surface.

Although pine mice are gregarious, they are often quarrelsome when first placed together. Fighting also occurs during sexual activity, and the male often suffers severe injury during such encounters. Cannibalism is common in pine mice. One animal rarely kills another, but individuals that die in a cage or are caught in a snap trap are often partially eaten.

Pine mice do not appear particularly intelligent, but some occurrences may indicate an ability to cope with new situations. On one occasion a female, while quarreling with a male, gathered all the cotton in the cage into a large ball which she pushed across the cage toward the male. As she reached the corner occupied by the male, she peered cautiously over the cotton, made a quick dive at the male in an attempt to administer a bite, and retired promptly behind the cotton. On the other hand, the circumstances of the incident may have been fortuitous only.

Communication.—Pine mice have a considerable variety of vocal notes which are regularly used. During fights, they are very noisy, emitting harsh chattering notes interspersed with tooth-chattering. A single or double note, reminiscent of the note of a wood thrush, is used as an alarm note, and is often repeated rapidly in a low conversational tone.

Well developed anal glands are present in this species, and appear to be especially large in breeding males. The activity of the female in rubbing her nose over the anal region of the male prior to mating may indicate that these glands have some part in stimulating the female to receptivity.

Locomotion.—The pine mouse is generally rather sluggish in its movements. Layne and Benton (1954) recorded a speed of 3.8 miles per hour over a 25-foot course, the slowest rate recorded for any mouse. They are relatively poor jumpers and climbers, although some individuals climb about a wire cage with considerable dexterity.

That pine mice can swim when necessary is evidenced by Stickel's (1948) observation of wet pine mice on floating debris during a Maryland flood. Captive animals will enter the water readily and swim with great celerity. All four feet are used, but most of the motive power is supplied by powerful thrusts of the hind limbs. Occasionally the animal will float while making no perceptible movement of the limbs.

The pine mouse excels as a burrower. Hamilton (1938) recorded one that burrowed from sight in forty seconds in a container of moderately packed loam. As observed in captivity, the head and neck are used in a shovelling motion to loosen dirt, which is scratched out and pushed backward with the forefeet. The forefeet are used in a backward and sideward motion, both to loosen dirt and to sweep it back to the hind legs. A powerful sweep of the hind limbs then throws away the loosened dirt. When the burrowing has proceeded for a foot or so, the mouse turns around and pushes the accumulated debris out of the tunnel with his head, thus making the characteristic dirt piles.

Animal associates.—Over its wide geographical and ecological range, the pine mouse may come into contact with most of the small mammals of eastern United States. At Ithaca, its associates include *Napeozapus i. insignis, Clethrionomys g. gapperi, Parascalops breweri, Sorex f. fumeus, Sorex c. cinereus, Peromyscus leucopus noveboracensis, Peromyscus maniculatus gracilis,* and *Blarina brevicauda.* At Kingston, where it is the most common species in the orchard, its associates include *Microtus p. pennsylvanicus, Peromyscus leucopus noveboracensis,* and an occasional *Blarina* or *Zapus h. hudsonius.* These animals often utilize the same runways and appear to occupy the same area.

The large nests of *Pitymys* provide a home for great numbers of small invertebrates. Insects include the springtail *Achorutes armatus* (Nic.) (Collembola), and a staphylinid beetle, *Philonthus laetulus* Say, (Coleoptera). Mites found in the nest include *Glycyphagus domesticus* (Degeer) and *Garmania bulbicola* (Oudms.).

Predators.—The fossorial habits of the pine mouse may protect it in a measure from predation. Nonetheless, it is taken to some extent by many predators. Latham (1950) has summarized data on predators of the northeast. He lists as predators of the pine mouse: barn owl, long-eared owl, screech owl, short-eared owl, great horned owl, barred owl, red-tailed hawk, red-shouldered hawk, broad-winged hawk, marsh hawk, red fox, gray fox and opossum. Other mammalian predators include the house cat (Rowley, 1902), dog (Saunders, 1932), raccoon and mink (Llewellyn and Uhler, 1952).

Kennicott (1857) placed a pine mouse in a cage with a short-tailed shrew, (*Blarina brevicauda*), and in the fight which ensued the shrew appeared to be suffering defeat. Kennicott separated them before either was killed. A repetition of this experiment, with a pine mouse and a short-tailed shrew in a cage about 8 by 12 inches, had no such result. The shrew did not attack the mouse, but when it approached the pine mouse it was driven away. The pine mouse never showed any sign of alarm, and never pursued the shrew after driving it off. Hahn (1909) saw a *Blarina* carrying an adult pine mouse that was not yet dead, and it seems certain that the shrew is a predator of the pine mouse in some degree wherever they occur together.

Diseases and parasites.—Little is known of the diseases of this species. Hamilton (1938) described a disease that caused loss of large patches of skin and fur, and led to paralysis and death. Pearson and Pearson (1947) took a pine mouse that was partially naked, possibly from the same cause. Captive mice frequently succumb to undetermined ailments. Autopsy often reveals an enlarged spleen and a necrotic appearance of the liver. In others, the large intestine is crammed with hard fecal matter, indicating constipation. No signs of respiratory ailments were noted during this study.

Internal parasites have been seldom reported from the pine mouse. Occasional tapeworm larvae have been taken from the livers of pine mice at Kingston, while eggs of a small nematode, *Trichurus* sp., have been found in the small intestine. By far the most abundant internal parasite in this area was a large acanthocephalan, *Moniliformis clarki* (Ward) (Benton, 1954). In the autumn of 1951 and the summer of 1952, this parasite was found in most of the mice col-

lected. Few were taken during the spring months. The worms, which infest *Microtus* in the same locality, are found in the small intestine. One mouse had 22 of these worms packed in the intestine so tightly that it could hardly have permitted the passage of a normal amount of food. These worms reach lengths in excess of 125 mm., and when present in numbers they may cause loss of weight and general debilitation. There is no evidence that they actually cause death of the host.

Ectoparasites are often abundant on pine mice. At Kingston, a louse, *Hoplopleura acanthopus* (Burm.) was so abundant that hundreds could be taken from a single mouse. The most abundant and widespread mite infesting the pine mouse is *Haemolaelaps glasgowi* (Ewing). This mite is widespread on voles and other small mammals, and apparently occurs wherever the pine mouse is found. Other parasitic mites found in the nests of pine mice during this study include *Laelaps alaskensis* Grant, *Myocoptes* sp., *Dermacarus* sp., and *Pygmephorus* sp.

Fleas are seldom common on pine mice. The more than one hundred mice taken at Kingston did not yield a single flea. *Ctenophthalmus pseudagyrtes* Baker, a non-specific parasite of small mammals, was taken at Ithaca, and has been widely reported from pine mice in other places. *Doratopsylla blarinae* C. Fox was taken from a pine mouse in New Jersey. This and other occurrences recorded in the literature are accidental transfers from the true host, in this case the short-tailed shrew.

SUMMARY

A study of the pine mouse *Pitymys pinetorum scalopsoides* was conducted at Ithaca and Kingston, New York, during 1950, 1951, and 1952. Its presence in an orchard was first observed after dying trees indicated damage already done. Signs of presence are difficult to observe since these mice are fossorial, and utilize runways and burrows of other species. They may occur in almost any habitat, but are largely restricted to light soils, and appear to prefer dry areas.

Trapping data indicate slightly more activity at night than by day. The average home range of 13 individuals, determined by re-trapping, was 21 yards in diameter. Individuals released up to 150 feet from point of capture returned promptly to the home area.

Populations were not evenly distributed throughout the orchard studied. In some areas five to ten mice were taken from a single tree, while other areas showed no sign of pine mouse occupancy. No evidence of cyclic population tendencies was noted in the period of the study.

A reproductive season extending from January to October was found in this population. Some males appeared to be capable of breeding in late December, but the earliest breeding occurred about January 20. The young lose the juvenile pelage at two to three weeks, and begin the molt to adult pelage at about three weeks. Adult pelage may be reached at seven to ten weeks of age. Molting of adults occurs in late fall and early winter, in early spring, and may occur throughout the summer.

Pine mice are poor runners and climbers, but swim and burrow with ease and

rapidity. The head, neck and fore feet are used to loosen the dirt, which is discharged backward by the hind feet.

Moniliformis clarki (Ward), an acanthocephalan worm, was a common endoparasite at Kingston. Common ectoparasites included the louse *Hoplopleura acanthopus* (Burm.) and the mite *Haemolaelaps glasgowi* (Ewing). No fleas were taken at this locality, though *Ctenophthalmus pseudagyrtes* Baker was removed from pine mice at several other places.

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BIOLOGY OF THE INDIAN MONGOOSE IN PUERTO RICO

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At present the wild mammalian land fauna of Puerto Rico is limited to a few species of bats, rodents, and the Indian mongoose (*Herpestes auropunctatus auropunctatus*). In 1877 the mongoose was introduced into Puerto Rico (Colon, 1930) from Jamaica, British West Indies, for rat control, since at that time the methods of rat control employed on sugar plantations were inadequate to cope with the severe problem that existed. Only at first did the mongoose appear to give effective control of rats. This limited benefit was soon offset by complaints of damage to agricultural interests. Recently, the mongoose has been incriminated as a reservoir and vector of rabies.

In Puerto Rico during the period from 1911 to 1933 only 21 cases of rabies were diagnosed in dogs and farm animals, and none were found in mongooses (Tierkel *et al.*, 1952). From 1933 to 1950, the island was considered one of the few rabies-free areas in the world. In the early part of 1950, studies by the Communicable Disease Center and the Commonwealth of Puerto Rico Department of Health showed that the mongoose was the important reservoir and vector of rabies in Puerto Rico (Tierkel *et al.*, *loc. cit.*). This was the first time rabies had been reported in the Indian mongoose. In South Africa, however, the yellow mongoose (*Cynictis penicillata*) has been recognized as a vector of rabies since 1928 (Snyman, 1940).

The mongoose has also been shown to have a high incidence of infection of the human leptospiral organism (Yeager, 1952). The danger of mongooses to human health and safety warranted the prompt action of the Public Health Service to find a method for controlling this animal (Pimentel, ms.). A study of the biology of the mongoose was undertaken to provide guidance in planning

the control project. During the study, which was carried on between July 1951 and November 1952, a total of 398 mongooses were live-trapped; 260 of these were taken into the laboratory and held for various periods of time.

TRAPS AND BAIT

For live trapping of mongooses during this study, two types of local box-type traps 6 inches wide, 8 inches high, and 20 inches long were used. The Javio trap had a wooden frame covered with 4-mesh hardware cloth. The St. Croix trap was constructed of wood. After the addition of a lock-catch to the St. Croix trap to prevent the mongoose, once trapped, from opening the door, no difference was found between the two traps in their effectiveness in capturing mongooses.

The most economical meat-type bait for this carnivore was found to be fish. Fresh fish under the tropical conditions decomposed in two days and the mongooses refused to take the rotting fish after the second day. To find a long-lasting bait, salted codfish, seared codfish, sun-dried desalted codfish, and sun-dried fresh fish were tested both in the laboratory and in the field.

In the laboratory test the mongoose refused to eat heavily salted fish. Thus sun-dried desalted codfish and sun-dried fresh fish were compared. Five adult male and five female mongooses were caged separately. Preliminary observations in the laboratory had indicated that an adult mongoose consumed about two ounces of fish per day. In this test, five ounces of sun-dried fresh fish, and five ounces of sun-dried desalted codfish were placed in each cage daily to insure each animal having a choice from an ample amount of bait. The bait was replaced with fresh material daily during a one-week test, and a daily weight record of the uneaten portion was kept.

The average amount of sun-dried fresh fish and sun-dried desalted codfish consumed in one week was 9.5 and 5.6 ounces, respectively. The quantity of sun-dried fresh fish consumed was significantly greater at the 1 per cent level (Snedecor, 1946) than the amount of sun-dried codfish eaten. Two of the ten test animals preferred codfish to fresh fish, however.

In the field trapping test, half of the traps used were baited at random with sun-dried fresh fish and the other half with sun-dried desalted codfish. There was no significant difference between the number of animals trapped with either bait. This may indicate that in the field the mongoose is not as particular as when caged and that it will be attracted to and eat either of the baits. Sun-dried fresh fish was used in all subsequent trapping tests, however, since it was more economical than the codfish.

HABITAT

Puerto Rico has many diversified areas which include: the arid south and humid north portions of the island; seacoasts, mountains, grasslands, and forests; sugar cane, pineapple, coffee, dairy, fruit, and poultry farms; and suburban and urban areas. Mongooses were found in all the above-mentioned habitats, except in forested and in urban areas. The mongoose, which is not a tree climber, apparently avoids forested areas because they offer poor shelter and little chance to obtain food. In the Dominican Republic the aversion of the mongoose to forests is such that the natives keep their hens with young chicks in the cocoa groves (Seaman, 1952). The largest mongoose population was found in dense grass, two to seven feet high, especially near the borders of small streams in lowlands. In this type of habitat population studies indicated there was a density as high as one mongoose per acre.

SEX CHARACTERISTICS AND REPRODUCTION

The sex ratio of a group of 279 trapped mongooses was 144 males to 135 females. These results differ from those reported by Baldwin *et al.* (1952), who found a large excess of males over females trapped in Hawaii. When a population of mongooses was

TABLE 1.—*Results of trapping mongooses on a 70-acre plot in Puerto Rico for 11 weeks with 100 traps*

Week	Male	Female	Total
1	16	15	31
2	7	7	14
3	1	3	4
4	6	3	9
5	0	1	1
6	1	1	2
7	0	2	2
8	0	2	2
9	2	2	4
10	2	1	3
11	1	0	1
Total	36	37	73

trapped out of an area in Puerto Rico no significant difference was found in the sex ratio of the group of animals taken first as compared to the animals taken last (Table 1). When mongooses were trapped, marked, released, and then retrapped, no difference was found between the males and females in regard to trap shyness.

The adult male mongoose had an average body length of 13.0 inches (range from 11 to 14 inches), an average tail length of 10.6 inches (range from 9 to 12 inches), and an average weight of 21.2 ounces (range from 16 to 33 ounces). The adult female mongoose was smaller. She had an average body length of 11.7 inches (range from 10 to 13 inches), a tail length of 9.3 inches (range from 8 to 10 inches), and an average weight of 16.0 ounces (range from 11 to 24 ounces).

The breeding season ranged from January to October. Observations of the distribution of pregnant and lactating females indicated that a large number of litters was born during March and April, and again during July and August. The majority of the females probably produce two litters a year in Puerto Rico.

From a total of 52 pregnant females, the number of fetuses averaged 2.1 and ranged from 2 to 4. Five sets of twin pups were born in the laboratory. In all cases the young were born within about a month after the females were taken to the laboratory, so the only indication obtained in regard to length of gestation was that it was more than 32 days. In the laboratory the females did not care for their young even when the female and young were not disturbed. In two cases the females killed and ate their young, and in a third case a female that had been receiving warfarin died from hemorrhage at the birth of the pups.

GENERAL HABITS

The mongoose was observed to be diurnal, with little or no activity at night. During a two-month test in which trapping was carried on from 6:00 A.M. to 6:00 P.M. and the traps were checked approximately every hour and a half, the greatest feeding activity was between the hours from 11:00 A.M. and 3:00 P.M. The animals sought shelter when it rained and did little or no hunting for two or three days if the rains continued for that length of time. Animals trapped during the second or third day of a rainstorm aways had empty stomachs.

The mongoose was observed to occupy burrows, some of which were in crevices of limestone rocks and in spaces under large boulders. The mongoose probably also took advantage of spaces around roots and logs.

SOCIAL HABITS

In the laboratory two newly trapped adult females were placed in separate cages, each of which already housed a mongoose that had been in the laboratory for two weeks. As soon as the animals were introduced into the inhabitated cages, a bitter battle took place between the male in the cage and the introduced female, and in the other cage the same occurred between the female in the cage and the introduced female. In less than a minute both introduced females were lying unconscious on the bottom of the cage and in an hour they were dead. Both of these dead animals were left in the cage for 24 hours to determine if hunger motivated the savage attack, even though both caged animals had been regularly receiving about two ounces of fresh fish daily. The male mongoose ate the left hind leg of the killed female, but no other feeding was noted. This substantiated the belief that both animals were amply fed and had killed for other reasons. It is possible that the caged animals were protecting their established homes.

In further studies, newly trapped adult animals were placed in cages together in the following combinations: Female with a female, male with a female, and male with a male. These animals got along well without fighting for over three months. The only exception to this occurred at feeding time when one animal would snap at the other if one piece of fish were given.

In the field, two mongooses were seen fighting savagely, but when the site of the battle was examined no indications were found as to motivating cause. The only instances of mongooses seen peaceably hunting together were mothers with young, or two newly grown, young animals hunting together.

HOME RANGE

There are many conflicting observations about the migratory habits of the mongoose. Spencer (1950) reported that the mongoose is largely migratory with no specific home range, and that the estimated average daily foraging range was ⅛ to ¼ of a mile. Baldwin *et al.* (1952) observed that in some areas small groups of individuals moved together; however, in another area where food was plentiful mongooses were found to remain in the immediate vicinity for six months. Reports by Seaman (1951) at St. Croix, U. S. Virgin Islands, and Diaz (1951) in Puerto Rico indicated the mongoose is not migratory but has a home range.

Support for the theory that the mongoose has a home range instead of being migratory was obtained in this study from the trapping records. At Carolina, 90 per cent of the animals trapped in a 60-acre test plot were taken in the first eight days of a five-week trapping period. More evidence was collected at Roosevelt Roads where 62 per cent of the mongooses trapped in a 70-acre plot were taken from the area in the first two weeks of an eleven-week trapping period (Table 1).

The diameter of the home range of the mongoose was needed to give guidance in the setting of poison bait stations in field control studies. A heavily grassed area about 1000 feet square at Roosevelt Roads was selected for the home range study. A total of 100 Javio traps baited with sun-dried fresh fish were set at 100-foot intervals throughout the plot. The traps were checked once a day for a period of eighteen days. All mongooses captured were marked and then released immediately.

The toe-clip method was used to mark each animal captured. This entailed first releasing the animals from the Javio trap into a specially constructed cage 9 inches wide, 9 inches high, and 20 inches long. The sliding front door of this cage was closed. A plunger-like arrangement was then moved forward, forcing the mongoose to the front sliding door. The front door was opened wide enough to allow the investigator to reach in with pincers and draw out one leg so the toes could be clipped.

Forty-seven mongooses were taken a total of 83 times during the eighteen-day period. There was a definite indication of trap-shyness after an animal had once been taken and released. Eleven mongooses, however, were trapped from three to seven times each. The

diameter of the home range of the mongoose was estimated by measuring the greatest diameter between catches. The average home range diameter for these animals was 320 feet, varying from 100 to 700 feet. The average home range of the male was 412 feet (varying from 300 to 500 feet) while the average home range of the female was 267 feet (varying from 100 to 700 feet).

From the data obtained it was calculated there was about one mongoose per acre in the test plot.

PARASITES AND ENEMIES

Of the total of 396 mongooses trapped, 210 were examined for ectoparasites and intestinal helminth parasites. One animal was infested with cat fleas (*Ctenocephalides felis*), and another appeared to have a light case of mange, but when skin scrapings were examined no mites were found. The skin condition may possibly have been a bacterial or fungal infection. No intestinal helminth parasites were found. A hair ball 7/8-inch in diameter was taken from the stomach of one mongoose.

The main enemies of the mongoose in Puerto Rico are humans, dogs, cats, and possibly ants. Man is the most important enemy. Dogs kill a few animals, but the majority of the mongooses escape easily by moving swiftly into dense cover. There are so few cats in Puerto Rico that their effect upon the mongoose population is considered negligible. The fire ant (*Solenopsis geminata*) has been observed killing young rats, and therefore is presumed to be capable of killing very young mongooses in burrows.

FOOD HABITS

A total of 56 mongooses were trapped at Roosevelt Roads in a habitat that had a dense grass cover with scattered brush areas. The stomachs of the mongooses were examined for the foods they contained. Of a total of 315 specimens in the 56 stomachs, 88.9 per cent were animal, and 11.1 per cent plant material. Insects made up 56.4 per cent of the animal specimens, and the remainder included: reptiles, 17.1; myriapods, 12.1; arachnids, 7.9; mammals, 2.9; crustaceans, 1.4; asteroids, 1.1; and amphibians, 1.1 per cent. More insects of the order Orthoptera were consumed than of the other insect orders. This may be partly due to the large size and availability of the Orthoptera. The maggots, ants, and other small insects may have been on the fish bait used to trap the animal. Some of the insect remains may also have come from insects that the ingested reptiles and amphibians had consumed (Wolcott, 1948).

No remains of birds were found in the stomachs, but this does not mean the mongoose does not prey upon birds when it has the chance. There are relatively few birds in Puerto Rico, and the majority dwell above the reach of the mongoose. Farmers throughout the island complain that they are unable to let poultry run loose in their yards because of the mongoose's depredations upon the flocks.

The evidence obtained in support of the mongoose as an effective predator of rats in the type of area trapped was not encouraging. Only 2.5 per cent of the stomach contents were rat remains. All of the rats identified in the stomach contents were half-grown tree rats (*Rattus rattus*).

The mongoose was found to prefer fresh meat to carrion. Fish that had been allowed to spoil for 24 hours was hardly touched by the mongoose. The animals also starved themselves for 24 to 48 hours before eating starchy foods such as bread.

DISCUSSION

The presence of the mongoose is clearly disadvantageous to human health and safety in Puerto Rico. Since 1950, when the animal was shown to be the important reservoir and vector of rabies on the island, efforts have been aimed at its eventual extermination.

Concerning agriculture, the status of the mongoose is still questionable. For about 15 years after 1870, when the mongoose was introduced into the West Indies, it was given great publicity regarding its effectiveness against rats. Since all the reports at that time

were in favor of the mongoose, the animal probably had a marked initial effect upon the large rat population.

The exact date when the tree rat and Norway rat (*Rattus norvegicus*) were introduced into the West Indies is not known. The tree rat is believed to have been introduced into Trinidad, British West Indies, about 1658 (Myers, 1931), and was brought into Puerto Rico soon after that date. The Norway rat was introduced some years later. By 1877, when the mongoose was introduced into Puerto Rico, there is little doubt that the rat population on the island consisted both of *R. rattus* and *R. norvegicus*. The Norway rat was probably the dominant species, for wherever the Norway rat has gone, reported Zinsser (1935), "it has driven out the black rat and all rival rodents that compete with it."

The mongoose had ample opportunity to attack and control the Norway rat in the suburban and farm areas of Puerto Rico, since the Norway rat is a ground nesting animal. Rats trapped during this study in suburban and farm areas have been only tree rats, while in an urban area of San Juan trapping indicated that the rat population consisted of a ratio of two Norway rats to one tree rat. To what extent the mongoose reduced the tree rat population is not known. Since the mongoose exterminated the tree rat's superior competitor, however, there is the possibility the tree rat population may have actually increased in some areas because of the mongoose.

Another example of this competition between the two rat species existed on the islands of Hawaii. On Kauai Island where the mongoose had not been introduced, the rat population consisted predominantly of the Norway rat; while on Maui and Oahu Islands where the mongoose was liberated, the predominant species was the tree rat (Barnum, 1930).

In the most desirable mongoose habitat in Puerto Rico, which as previously mentioned was dense grass 2–7 feet high, the ratio of mongooses trapped to tree rats trapped was 18 to 1. While on the borders of brush and forested areas, which is poor mongoose habitat but good tree rat habitat, the ratio of mongooses to rats taken was 1 to 3. The mongoose is able to prey upon the tree rat population in the densely grassed areas because there are no trees or bushes for the tree rat to climb and thus escape.

The activity paths of the mongoose and the tree rat do not cross frequently, for the mongoose is most active in mid-day, while the rat is mainly a nocturnal animal. This reduces the chances for the mongoose to affect the rat population. The total effectiveness of the mongoose against the tree rat might also be questioned because of the high biotic potential of the latter animal.

As shown in the study of food habits, the mongoose consumed some destructive and dangerous arthropods and also some beneficial ones. In general, this seems to have slight economic significance.

The leaf lizard, *Anolis* spp., made up a large portion of the diet of the mongoose. The mongoose apparently affects the leaf lizard population, for in areas where mongooses are scarce there are tremendous numbers of *Anolis* spp. The mongoose also has a considerable effect upon the other members of the class Reptilia, as substantiated by a study conducted on two islands of Puerto Rico by Schmidt (1928). He found the ground lizard (*Ameiva exsul*) abundant on Culebra Island where the mongoose had not been introduced, while on Vieques Island the mongoose was said to have exterminated the ground lizard and snakes. The mongoose has had similar disastrous effects upon the ground lizard in the other islands of the West Indies where the mongoose has been introduced and has thrived (Myers, 1931).

In general, however, wildlife is relatively limited in Puerto Rico. This is probably not due to the mongoose, but more to predation on wildlife by man, since the island has some 715 humans per square mile.

SUMMARY

A biological study was made of the Indian mongoose (*Herpestes auropunctatus auropunctatus*), an important reservoir and vector of rabies in Puerto Rico. During the progress of the study a total of 398 mongooses were live-trapped;

260 of these were taken into the laboratory and held for various periods of time. Adults were found to weigh slightly more than one pound. Females produce a yearly average of two litters of two pups each. The animal has a home range, varying from 100 to 700 feet in diameter. The mongoose was observed to be diurnal, preferring a habitat of dense grass near small streams, and is carnivorous, preferring fresh meat to carrion. Insects and reptiles are the main foods eaten in the wild. Sun-dried fresh fish was found to be satisfactory bait for the animal. Evidence was obtained that the mongoose is not an effective predator of rats in Puerto Rico.

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BEHAVIOR PATTERNS IN A LABORATORY COLONY OF PRAIRIE DOGS, *CYNOMYS LUDOVICIANUS*

By Adam Anthony

Animal associations with different degrees of integration have been recognized to be so commonplace among organisms that sociality appears to be an universal phenomenon throughout the animal kingdom. Social life in the broad sense of animal aggregations has been demonstrated in various species ranging from the protozoa to the mammals (Allee, 1935). However, the culmination of social organization based on *conscious* cooperative and disoperative reactions among individuals is found only in vertebrates, and as one might expect, is most remarkably illustrated in the higher vertebrates, the birds and mammals.

An extensive study of the seasonal reproductive activities of the black-tailed prairie dog, *Cynomys ludovicianus*, afforded an excellent opportunity to observe societal interactions in a laboratory colony of prairie dogs. This paper represents a summary of the observations made on such a colony during a four year period. Attention is focused on the analysis of group organization in terms of leadership, correspondence, huddling, assimilation and other behavioral activities, and the interpretation of these activities with respect to their adaptive significance.

A total of approximately 250 male and female prairie dogs was observed for more than four years. Although the majority of these were used in endocrine experiments, an untreated group of about 20 to 40 animals was maintained throughout the period of study. All of the prairie dogs were obtained from the Wichita Mountains Wildlife Refuge in Cache, Oklahoma.

GENERAL OBSERVATIONS

The prairie dog is a diurnal rodent having a short mating period limited to late January or early February. A detailed description of the black-tailed prairie dog, its habitat and reproductive cycle can be found in earlier papers (Anthony and Foreman, 1951; Anthony, 1953).

Some of the characteristic behavioral reactions of individuals were observed under controlled laboratory conditions to permit a more careful analysis of the effects of various laboratory treatments on behavior. A brief description of these activities follows.

Vocalization.—Three types of barks can easily be distinguished among the laboratory animals: (1) the low "chirr" or fighting bark occurs during aggressive contacts and is frequently followed by tooth chattering; (2) the high staccato bark, usually accompanied by tail wagging, apparently serves as a warning signal alerting other colony members, and (3) the very peculiar but characteristic "song bark" which is best described as an "all clear" signal. During this response the dog rises to its haunches, points its nose up and emits a high sound while falling back to all fours. This is repeated and picked up by other members so that a series is set up much like the wolf or coyote howl sequence.

Mouth contacts and grooming.—Among the tactile or contact responses that occur in prairie dogs is the "recognition" reaction which we have termed the

mouth contact. During a mouth contact the dog tilts its head at a 45° or 90° angle, opens its jaws and touches the open mouth of another dog which responds in a like manner. This is usually accompanied by tail wagging and is frequently followed by grooming.

Grooming in prairie dogs is similar to that found in other mammals where one member of a pair nibbles or bites through the fur of the other. Captive dogs appear to react in a positive fashion not only to grooming but to tactile stimulation in general. When petted by an observer docile dogs or pups turn over on their backs and remain in this position while their abdomen is scratched. They often respond to gentle handling by touching and moving their incisors over the skin of the investigator's hand without closing their jaws.

Huddling.—Another reaction which could be classified as a positive contact response is the huddling together of prairie dogs during inactivity or while sleeping. Although the adaptive significance of such behavior during cold weather is obvious, it isn't too clear why this should persist during the summer months. The tendency for dogs to seek darker regions may account for this, should the protection afforded by darkness serve as a stronger stimulus than the heat discomfort.

Burrowing.—A group of dogs was confined in a large indoor pen with a dirt floor a few feet in depth and connected with an outdoor screened enclosure. This was constructed in an effort to increase the incidence of breeding and also to permit the observation of burrowing habits.

Short tunnels having two openings were periodically built by dogs in the indoor pen. However, little information was obtained on burrowing habits since these tunnels were only used during chasing and playing activities. Dogs in smaller cages seldom engaged in playing antics; this and the failure to obtain breeding in small cage groups suggests that space may be a limiting factor influencing the degree of reproductive activity in this form.

Reproductive activity.—There was a noticeable increase in general activity of the captive colony during January and February. This was closely associated with the recrudescence of gonadal activity as the peak of the breeding season was approached. Although confinement had no effect on the development of the gonads themselves (Anthony, 1952), the breeding activity of caged dogs was apparently inhibited in some manner as evidenced by the low incidence of courtship behavior, sex aggression and mounting in captive males (successful mating and delivery of young was obtained on one occasion in the larger pen).

Hibernation and aestivation.—Sporadic rather than continuous hibernation occurs in *Cynomys ludovicianus* as evidenced by the frequent appearance of dogs above ground in the middle of winter (Greenwalt, 1950). Although dormancy was never observed in captive dogs kept at normal laboratory conditions, short periods of lethargy could be induced by very low temperatures. There are no reports of aestivation occurring in this species.

The black-tailed prairie dog differs in this respect from its northern relative, *Cynomys leucurus*, which goes into continuous hibernation in the winter and into aestivation during the summer (Stockard, 1929).

INDUCED BEHAVIOR CHANGES

The following considerations deal with the response of experimental groups of prairie dogs to various laboratory treatments.

Light.—An experimental group of animals was kept under continuous light exposure for a period of six months. A second group of three dogs was kept in continuous darkness for three months. Control animals were exposed to 12 hours of light and 12 hours of darkness daily.

There was no appreciable difference in the activity or the amount of food consumption of the "light" group as compared to the controls. Continual darkness, however, was accompanied by a decrease in activity as evidenced by normal body weight in spite of much lower food intake in the "dark" group. Although the three "dark" members consumed less than 25 per cent of the amount eaten by the same number of "light" or control animals, their weights were the same as weights of animals from the latter two groups.

Temperature.—The effects of low temperature on general activity were studied in 15 prairie dogs. Four dogs were placed in a dark constant temperature room (10°–13° C.) for one week. The immediate reaction to cold was a grouping together of the dogs, each huddled into a ball with its head between the forepaws. Shivering, increased wakefulness and greater food consumption also resulted from exposure to moderate cold. Associated with this was an increase in the urinary output which was maintained throughout the experimental period. The average volume of urine excreted by four males placed in the cold room on July 30, 1951 was 68 ± 7 ml./day per dog as compared to 48 ± 6 for the controls during the same one week period. Urine collected from four males after a six-week exposure period averaged 61 ± 17 ml./day per dog for the experimentals as compared to 30 ± 6 ml. in the controls.

Hibernation did not occur in animals kept at 10–13° C. as long as excess food (dog chow) and water in the form of lettuce and cabbage was supplied daily. When vegetables were removed from the diet, however, all dogs went into sporadic periods of dormancy. Initially these lasted for 2–3 days but became progressively longer (7–14 days) when the low water diet was continued.

Three animals kept in an outdoor cage at freezing temperatures (−20–+19° C.), lost considerable weight and went into a much deeper dormant state which was referred to as "cold narcosis" since recovery did not occur unless the animals were warmed. The inability to obtain water partly accounted for this since vegetables would freeze quickly in the cage. Critical temperature limits or survival time of dogs in cold narcosis were not determined although recovery by warming was obtained in two prairie dogs which had remained in a comatose state for 14 days.

Breathing is barely perceptible during cold narcosis and the body temperature approximates that of the cage interior. When warmed, these dogs slowly recover with an involuntary quivering of the body and extremities.

Sex hormones.—Testosterone proprionate was administered subcutaneously to 17 males in doses of 0.1 and 0.5 mgm. daily for two weeks during different months throughout the period of sexual quiescence. Increased tension and ex-

citability was noticed in most males toward the end of the treatment period. Even a cautious approach by the investigator was frequently met by angry chattering and threat responses with forepaws raised in a typical fighting stance. This was in agreement with our observations that captive males tend to be more difficult to handle during the breeding season.

Subcutaneous injections of estrogen (alpha estradiol diproprionate) given to five males for a two week period had no apparent effect on general acivity.

SOCIAL INTERACTIONS

Although the prairie dog has long been recognized to exhibit a high degree of social organization in the wild, there has been no attempt made to study the nature of this sociality in laboratory confined animals. An analysis was made, therefore, of certain manifestations of sociality in captive dogs. The following is a summary of studies on feeding activities, mouth contacts and the assimilation of individuals into new groups.

To facilitate the observation of the interactions between individuals, all animals were marked by clipping circular spots of hair from the back, sides and thighs. Behavioral data could then be collected from a point of concealment outside the animal room.

Feeding order.—Three to five dogs were assigned at random to 14 cages in our laboratory. When food dishes were placed in these it was noticed that all of the dogs could be arbitrarily divided into two groups: (1) those that immediately began eating and (2) those that exibited a delayed eating response; the latter dogs often remained in a corner of the cage until some time after the departure of the investigator. It was further noted that the same members of each cage usually initiated the feeding. In order to determine whether a definite feeding order was present in certain groups of captive dogs, three test cages were

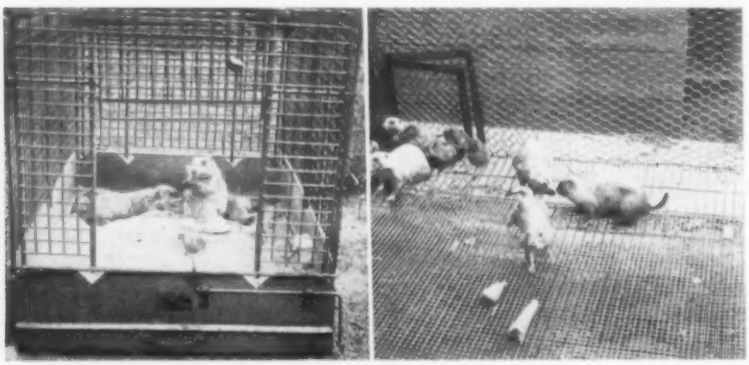

PLATE I

LEFT: Cage used in feeding experiments showing an alpha prairie dog eating at the central food dish.

RIGHT: Prairie dogs in an outdoor enclosure illustrating the recognition contact.

selected for more careful study. Each of these contained three marked dogs one of which seemed to eat earlier than the others. Ten observations were made on each group, food being withheld for two days before each observation period.

The results obtained indicated that a definite feeding order does exist at least in certain selected groups of animals. The behavior pattern was similar in all cases. When a food dish was placed in the center of a cage, one dog, designated as the "alpha feeder", initiated the eating sequence. After a short interval of time a second dog, "beta", began eating. The beta dog exhibited this delayed response 80 per cent of the time. The third dog of each group, designated "omega", usually remained passively huddled in a corner. The tendency of the omega dog to be the last to eat, to frequently take food and eat away from the food dish and to avoid contacts by remaining huddled in a corner gave evidence of its low rank in the feeding order.

Data were insufficient to draw any definite conclusions regarding sex and feeding seniority. Although either sex can be alpha in a mixed group, males were found to have a higher rank more frequently than the females.

Alpha dogs usually assume a central position at the feeding dish and are frequently larger in size than their cage companions. They also exhibit more general activity than dogs lower in the feeding order, frequently rattling the cage door and exploring the cage thoroughly after each departure of the investigator. Several preliminary tests suggested that the alpha feeders learned to raise an unlatched sliding cage door more rapidly than passive, lower ranking members; however, the possibility could not be eliminated that this was merely a chance occurrence directly dependent upon their increased exploratory activities.

Aggressive contacts were not observed in adequately fed dogs. On the other hand, after a period of food deprivation, snatching and threat reactions could be elicited among the alpha and beta feeders, the former having a slight advantage. Omega dogs voluntarily retreated into a corner at these times. As one might expect, alpha dogs are generally more easily excited and show more resistance to handling.

Young pups were found to display more signs of aggression during feeding than adults. Contacts in young included bites, nips directed at the nose, threats and retreats. The feeding order of young seems to be determined in part by a "peck-dominance" similar to that occurring in many avian and mammalian groups. The alpha feeder is usually the challenger and exerts varying degrees of dominance over members lower in the feeding order. In one litter of five young there was a marked difference in the weight gain of the alpha dog as compared to the other four. The dominant or alpha dog gained 200 grams over a four week period as compared to a 50–100 gram weight gain in his cage companions.

Assimilation.—To elucidate the interactions between members of different cage groups of animals the following tests were made: (1) introduction of an alpha or beta dog into a "select group", i.e. one having a well established feeding order; (2) grouping three alpha dogs together; (3) grouping three subordinate (omega) dogs together; and (4) introduction of young into a select group of

adults. At least six trials were made in each of these tests. The results obtained are summarized in the following.

The introduction of an alpha or omega prairie dog into a select group had no effect on the existing social order and moreover, did not appear to alter the social status of the introduced member. A new dog always underwent the recognition mouth-contact with the alpha member of the group into which he was placed. This was usually followed by similar contacts with other members. If the stranger occupied an alpha rank previously, a mutually cooperative attitude was apparently adopted between the two alpha dogs and equal dominance shared over the subordinates. Similarly, a low ranking dog retained its respective status in a new group.

When three alpha or three omega dogs were placed together there was no evidence of the presence of any hierarchal pattern of dominance, i.e. there is no feeding order evident when one divides high ranking and low ranking dogs into separate groups.

Young prairie dogs were found to be quickly assimilated into any group. Again this was accompanied by frequent mouth contacts and smelling of the genitals. Both males and females seem to give precedence to pups during feeding. Perhaps it would be well to mention that the young used in these studies were approximately four months old.

Dominance.—Some preliminary data on the frequency of mouth contacts have indicated that the dominance order in a prairie dog colony could be further analyzed in a manner similar to that used in "peck-order" studies of hen flocks and other animals. The following example serves to illustrate this.

Mouth contacts among three young females were recorded for a four hour period. A definite correlation seemed to be present between the number of contacts initiated and the social rank of a dog as previously ascertained by studies of feeding and other activities. The alpha female (α-F) initiated 83 per cent of the contacts, the beta female (β-F), 17 per cent and the subordinate omega (ω-F), none, although the omega dog was involved in more than half of the total contacts during this period. (Table 1.)

Two young males, one dominant (α-M), and the other a subordinate (ω-M)

TABLE 1.—*Frequency of mouth contacts in cage I containing three young females*

Animal receiving contact	Animal initiating contact		
	α-F	β-F	ω-F
α-F	—	5	0
β-F	10	—	0
ω-F	25	2	—
Totals*	35	7	0

* The order of dominance was α-F > β-F > ω-F where > represents linear dominance over lower ranking dogs.

TABLE 2.—*Frequency of mouth contacts in cage I following introduction of a dominant male (α-M) and a subordinate male (ω-M)*

Animal receiving contact	Animal initiating contact				
	α-F	β-F	ω-F	α-M	ω-M
α-F	—	2	0	16	10
β-F	8	—	0	5	0
ω-F	12	1	—	0	0
α-M	25	3	0	—	5
ω-M	10	2	0	30	—
Totals*	55	8	0	51	15

* The order of dominance was α-M $\rightleftharpoons$ α-F > β-F > ω-F and α-M $\rightleftharpoons$ α-F > ω-M where the symbol $\rightleftharpoons$ represents more or less equal dominance by the two despots.

were then introduced into the cage with the females. The results of a three-hour observation period are summarized in Table 2. The dominant female made more contacts than the dominant male; however, about 90 per cent of the contacts initiated by the male were aggressive, followed by nips directed at the female's nose or by retreats by the female. Evidently both α-M and α-F maintain a dominant position over the other members, the male having a slight advantage over the female when first introduced into the cage. Exclusive male dominance, however, was not established. After a few days contacts between the two alpha dogs were minimal. Both moved freely about the cage showing no avoidance reactions, feeding together and generally displaying equal seniority over the rest of the group.

It was mentioned earlier that mouth contacts are frequently followed by grooming. Lower ranking dogs always passively submit to these activities; in fact, they often responded by rolling on their backs thus exposing their abdomen to further grooming by an alpha dog. This behavior is reminiscent of the submission response found in other mammals where the voluntary exposure of the most vital region of the body to the despot is interpreted as a sign of surrender and subordination.

Once the social status of each dog is ascertained by other members of a small cage group, recognition and other physical contacts occur less frequently and often may not be elicited for long periods of time. Presumably space is an important factor since the frequency of contacts among dogs contained in our larger pen did not seem to be markedly reduced even after prolonged internment.

Although time did not permit an extensive investigation of the peck-order in prairie dogs, the few preliminary tests did serve to confirm some of our conclusions regarding the existence of a certain degree of dominance and subordination among captive dogs. The data also indicate that the study of certain behavioral patterns such as the recognition contact could be used in the analysis of the social organization of community groups of dogs in the wild.

DISCUSSION

All of the evidence obtained from behavioral studies of captive dogs indicate that cooperative rather than disoperative activities provide the fundamental basis for the high level of social organization in the prairie dog.

Those activities which may be considered as primarily cooperative or integrative include the various barks, recognition responses, huddling, grooming, as well as related activities such as burrowing, chasing and playing. In all of these, several or many individuals may be involved.

Although a large variety of vocalizations are used by the prairie dog in response to different stimuli or situations, they fall into two general categories: (a) those that are mainly of concern to the individual and have no apparent effect on the rest of the colony and (b) those that elicit a definite response in many dogs. Tooth chattering for example, which occurs during disputes, is limited to one or two individuals whereas the warning bark and the song bark exert a general effect on the colony and can be aptly referred to as integrative. Warning barks act to alert an entire colony and elicit similar barks in other members; the song bark has an opposite effect and is best described as an "all is well" signal. The latter response was frequently given shortly after our departure from the laboratory. Dr. King (1950) has also reported this call as occurring in a colony following the passage of a predator such as an eagle in the field.

Many behavior patterns such as territory defense, burrowing, and courtship behavior were not observed in the laboratory presumably because natural conditions could not be simulated. That space is an important factor was evidenced by the appearance of some of these activities when dogs were placed in a larger pen. In nature, a small family group or coterie (comprised of approximately eight individuals) alone occupies an average area of about 0.7 acres. (King, 1951).

Our laboratory studies indicate that sociality at the small group level is maintained to a limited extent in captive animals. An attempt has also been made to show that this sociality is actually based on a dominance order. The social status of a particular dog was observed to be dependent upon a number of related activities. Those which seemed to be associated with dominance and leadership are: (a) movement about the cage with no avoidance of other dogs, (b) seniority in the feeding order, (c) presentation of the mouth contact, (d) grooming of subordinates and (e) initiation of the song bark. Signs of subordination on the other hand include the following: (a) passive avoidance of superiors, (b) delayed eating response, (c) passive submission to mouth contacts and grooming and (d) positive response to grooming by lying on the back.

Although social interactions have been interpreted in terms of dominance and subordination, it is important to point out that the basis for the existing dominance order is quite different from that described in other mammals. There is a minimal amount of aggression and competition among prairie dogs so that group cohesion in this species is mainly dependent upon integrative activities; conversely, in animals such as mice, rats, ground squirrels, etc., despotism (in the strict sense of aggressive dominance) seems to be the important factor in establishing the social hierarchy (Allee, 1945).

Sociality based upon cooperative mechanisms seems to hold true also for prairie dogs in nature. There is usually no discord within coteries and aggression is limited to fighting off intruders from adjacent territories. One dog usually maintains a position of seniority in his coterie and acts as the protective custodian of the territory which his group occupies (King, 1951).

In social studies of this sort it must be understood that one determines the position of a dog in the social gradient only on the basis of objective evidence. Although it was not stated explicitly, there is considerable variability in prairie dog behavior and there are many exceptions to the criteria of dominance and subordination listed above. For example, subordinate dogs frequently seek mouth contacts with dominant dogs and mutual grooming may ensue. Such behavior makes it difficult at times to ascertain the social status of a particular dog unless observations are extended over a considerable period of time.

SUMMARY

The social behavior of a captive colony of prairie dogs was studied during a four year period from 1948–1952. It was found that there is a very highly developed communication system in this species. This is based on a variety of vocalizations that appear to increase group cohesion of the colony as a whole.

In addition to cooperative activities that serve to unify a large group of animals, other forms of behavior such as recognition contacts and grooming act as integrative elements at the smaller group or family level. The integration at the small group level is expressed in the form of a dominance order which can be demonstrated by the analysis of feeding behavior or the analysis of the frequency of physical contacts between individuals.

Disintegrative activities, such as competition for food, territory disputes, sex aggression during the mating season or contests between high ranking dogs in small groups did not occur to any appreciable extent in the laboratory colony.

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THE BRAIN OF THE CHIMPANZEE AT THE TIME OF BIRTH (MYELOGENESIS)

By WALTHER RIESE

The history of our knowledge of the structure of human and animal brains can be divided roughly into three chapters according to the methods used and the anatomical constituents studied. Gross inspection and dissection were significant of the first chapter, that of *morphology*, which goes back to antiquity and which extended at least until the second half of the 19th century. By far the greater part of our actual and comparative knowledge of the brain was gained by the study of the nerve *fibers*, more specifically of those fibers that are in possession of myelin sheaths. Most of our textbooks carry pictures of myelin stained sections as informative material. The study of the architectural arrangement of the nerve *cells* stained with anilin dyes or impregnated with metals was undertaken in the most recent period of brain research. The investigation of the regional variations of the individual cells is still far from being completed. All of the three methods have been used for the study of the embryonic brain. Our knowledge of the human and animal infant brain still is very scarce.

The purpose of all these studies was either purely descriptive or functional, namely to correlate nervous structures with nervous functions, i.e., movements and sensations. It goes without saying that little reliable knowledge is to be expected by the study of the undisturbed behavior of an adult individual, human or not, whose central nervous system is intact; one just does not know which parts of the brain are thrown into action in an intact individual, and to what extent. Therefore, one turned to experimentation, either by the neurophysiologist or by nature, as in malformation and disease. Thus was increased considerably our comparative knowledge of the brain and its activities. The comparative observation of immature individuals, and the correlation of their behavior with the central structures already formed or still unfinished promised new insights into the comparative embryology of the brain. The study of the spontaneous or experimentally produced behavior of early developmental stages is relatively easy in lower species; the knowledge gained thereby remains linked with the name of Coghill. But the same type of study encounters great difficulties when applied to the various intra-uterine stages of the mammalian embryo;

still an increase in our knowledge of the activities of the immature mammalian brain was obtained by this method, particularly in Switzerland and this country.

I selected the behavior and the brain of mammals at the time of birth as test objects for our problem. Four years of uninterrupted observation of the behavior of different species at the time of birth at the Zoologic Garden in Paris in combination with anatomical investigations of the specimens observed, afforded an unusual opportunity for these studies. As a rule, the new-born mammal displays a behavior different from that of the adult, implying, however, certain elements indispensable for a sustained extra-uterine life, such as orientation and locomotion, and leaving alone the autonomic functions of respiration, circulation, digestion, and temperature regulation. But the developmental stage that the mammalian brain reaches at the time of birth was found to be very different in different species. The conclusion was reached that the same behavior was to be correlated with structures very different as to their degree of maturation. The results of the study of the structure and function of the brain of the opossum (Riese, 1945) at the time of birth seemed to justify the most far-reaching conclusions. After a gestation period of only about $12\frac{3}{4}$ days, this mammal is born with a central nervous system recalling the earliest stages of brain development. No cortical structure is formed so far. Nevertheless, the new-born opossum displays a complicated and purposeful motor activity. Should this be interpreted as a spinal mechanism, it would have to be correlated not only with an immature spinal cord as a whole but also with immature nerve cells (neuroblasts). The closer the species compared with one another, the more conclusive the results. Since the study of the structure and function of the human brain still remains the preferential subject, the opportunity given by Dr. K. S. Lashley, The Yerkes Laboratories of Primate Biology, Orange Park, Florida, to study the brain of an anthropoid at the time of birth was most welcome. The cerebral cortex of the chimpanzee, *Pan satyrus*, was found to be finished as to cytoarchitecture, but not as to the structure of the individual cell. The structural plan of this cortex was found to be the same as that of the new-born monkey (*Macaca cynomolgus* L.) (Riese, 1940) and human infant; but as the behavior of the chimpanzee, monkey, and man is different at the time of birth, the same cortical organization must be correlated with different behavior.

MYELOGENESIS IN A STILLBORN CHIMPANZEE AFTER 204 DAYS GESTATION PERIOD

The *pontine* level was the lowest one that could be studied in this specimen. The myelination of the cranial nerves (V, VI, VII, VIII) entering the brain stem at this level, was conspicuous. The same holds true for the *trapezoid body*. But the perforating fibers of the pons and the *pyramidal* tracts still lacked myelin. Some fine fibers, most probably belonging to the acoustic system, crossed the midline in the dorsal region. Myelinated fibers reached the *cerebellar nuclei* from the brain stem; others could be seen in the cortex of the *vermis*. At higher levels, myelination of the *brachium conjunctivum*, the *medial and lateral lemniscus* was conspicuous. There were also strongly myelinated *fasciculi long. dors.*; from

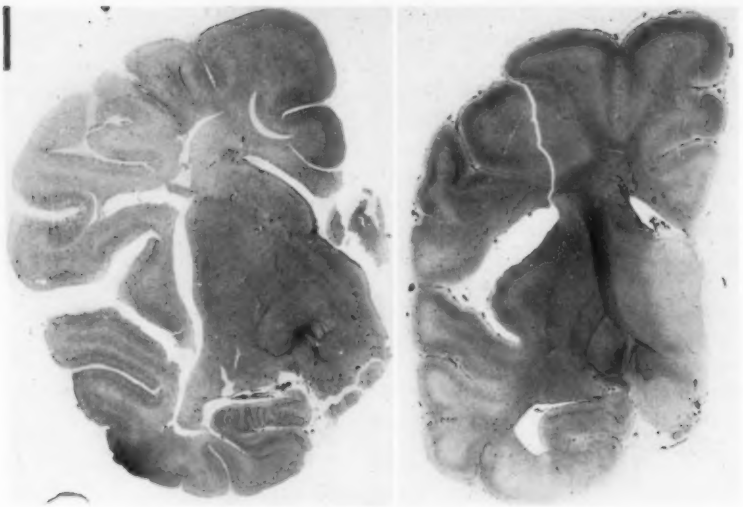

PLATE I

LEFT: Cerebral hemisphere of a stillborn chimpanzee after 204 days gestation period. Myelinated pallido-fugal connections are crossing the internal capsule still lacking myelin. RIGHT: Cerebral hemisphere of a 12 days old chimpanzee. Myelination of the dorsal segment of the internal capsule, pallidum, ansa lenticularis. Myelination beginning in the corona radiata. No myelination as yet in the temporal lobe (acoustic endings).

each one originated fine fibers crossing and decussating in the midline. The only myelinated system in the *cerebral* hemisphere (Pl. I, Left) was that of *pallido-fugal* fibers, many of which crossing the still unmyelinated *internal capsule* to reach the *subthalamic nuclei*, which were provided with a strongly myelinated capsule. The *bundle of Vicq d'Azyr* was myelinated. Generally speaking, after a gestation period of 204 days, the myelination of the chimpanzee corresponds to that of an 8 months old, i.e. 240 days old, human fetus.

MYELOGENESIS IN A 12-DAY-OLD CHIMPANZEE

Generally speaking, myelination in this individual was far in advance of the younger one. At *spinal* levels the *posterior columns* and the *spino-cerebellar tracts* stood out prominently because of their complete myelination. Myelination was far less advanced, though still conspicuous, in the *tractus mesencephalo-spinales; fasciculi reticulo-spinales and fasciculi fundamentales funiculi ventralis.* No myelinated fibers were found in the *tractus cortico-spinales laterales.* Nor was the area of the *tractus rubro-spinalis* myelinated. The *commissura alba ventralis spinalis*, however, was composed of myelinated fibers. At the highest spinal level the *decussatio lemnisci medialis* and the *eminentiae trigeminales* were found to be myelinated.

In the *medulla oblongata* the myelination of the *pyramids* was at its initial

stage. The *fibrae arcuatae internae, fibrae olivo-cerebellares, fasciculi solitarii* were strongly myelinated. All *cranial nerves* were strongly myelinated; at the *pontine* level myelination was obvious in lateral regions of the *brachia pontis* (still almost devoid of myelin in a 16-day-old human infant). The *brachia conjunctiva* seemed to possess their complete myelination. The myelination in the *cerebellum* was much in advance of the younger individual, particularly in the *vermis* and *cerebellar nuclei*. The white matter of the *flocculus* was intensely myelinated, while that of the *cerebellar hemispheres* still lacked myelin.

An intense myelination was found in the retro-lenticular segment of the *internal capsule* (Pl. I, Right). The ventro-medial part of it was not yet myelinated. Nor did the *striatum* (putamen and caudatum) possess myelinated fibers. But in all of the divisions of the *pallidum* myelination was obvious, particularly in the *laminae medullares* and the *ansa lenticularis*. In this region myelinated fibers from the *subthalamic nuclei* crossed the internal capsule. Strongly myelinated fibers reached the *red nucleus* from higher, probably pallidal and subthalamic levels. The red nucleus itself was also beginning to be myelinated. The third cranial nerve was also in full possession of myelin. At the same level myelinated fibers could be seen in the *lateral geniculate body*, particularly its capsule. The *tractus habenulo-interpeduncularis* was myelinated. The *posterior commissure* was the only commissure possessing myelin. Myelinated fibers could be seen in the ventro-lateral regions of the *thalamus*.

The *olfactory tract* was still deprived of myelin. The *optic tract*, however, as well as the optic chiasm were beginning to be myelinated. A small area of the *corona radiata* was myelinated. A few delicate fibers reached the *cortex* in the sensori-motor area. There were no myelinated fibers connecting neighboring convolutions.

INTERPRETATION IN THE LIGHT OF TIME

What makes the material here studied particularly valuable is the precision with which the ages of both these individuals could be determined. We are thus able to identify the stages of myelination reached, with those in the human subject, and to make a comparative study of myelogenesis in terms of time. In fact, an identical myelogenetic stage is reached after 8 months, i.e. about *240* days of intra-uterine life in the human embryo, after a gestation period of only *165* days in the macaca, and after *204* days in the chimpanzee. (The gestation period is 266 days for man, 231 days for the chimpanzee, and 165 days for macaca.) The conclusion is reached that *the degree of maturation is not in proportion to the gestation period*. When considering the primate group as a whole, the myelogenetic stage at birth seems to be characteristic of the species rather than the group. Compared with man, myelogenesis seems to be accelerated in the chimpanzee who needs considerably less time to reach the same myelogenetic stage. This comparative acceleration is in perfect harmony with that of morphogenesis and histogenesis (cytoarchitecture) in the same species. The reason may be found in the shorter life span and duration of infancy in the chimpanzee compared with man.

INTERPRETATION IN THE LIGHT OF FUNCTION

Correlation of anatomical structures with behavior must be made with caution. The physiological significance of the myelin sheath is still under debate. The neuropathologist is inclined to correlate certain syndromes with destroying lesions affecting the myelin sheaths, be it in a selective or disseminated fashion. The embryologist of the human brain tries to correlate the various steps in myelogenesis with the sequence of behavior patterns displayed by the individual during maturation. But there are lower mammals born with brains totally deprived of myelin and still capable of perfect and purposeful locomotion.

Among the primates myelogenesis is best known in man. Very little is known in subhuman primates, and myelogenesis has not been studied so far in the anthropoids. The behavior of the new-born human infant requires no further comment. Flechsig (1903) found considerable variations in the degree and extent of myelination, according to the length of the infants born at term. The human infant enters life with a different equipment of myelin, according to the duration of intra-uterine existence. Since the functional requirements that every human infant born at term has to meet are the same, they must be correlated with myelinated structures of different maturity. Variations in the degree of myelination at a given age were found also in other mammalian brains (Romanes, 1947). In contrast to the helplessness of man at the time of birth, the new-born chimpanzee displays an independent and rather evolved motor behavior (Riesen and Kinder, 1952). Twelve days after birth its myelination still limps behind that of a 16-day-old human infant. The cortical connections of the visual and acoustic centers are still completely deprived of myelin in the chimpanzee; they are, however, myelinated in a 16-day-old human infant (Minkowski, 1946*a*). Nor are the association fibers connecting neighboring convolutions myelinated in the 12-day-old chimpanzee, while, according to Minkowski (1946*b*), they are in possession of myelin in the 16-day-old human infant. Myelination as a whole appears to be much less intense in the 12-day-old chimpanzee, than in the 16-day-old human infant. This is a remarkable fact which strongly suggests that early extra-uterine life, in spite of the manifold stimulations it necessarily implies, does not precipitate the maturation of myelin in the central nervous system of the chimpanzee. In contrast, the opossum brings its nervous structures to maturation in the pouch of its mother within about 60 days, in total isolation from the outside world and its stimulating agents. One may assume that, at the time of birth, the chimpanzee reaches that stage of structural maturation indispensable for extra-uterine life, and that there is no immediate need for an early extra-uterine acceleration of myelogenesis.

The conclusion is reached that *a comparatively more mature motor behavior is compatible with a comparatively less mature state of myelination*. This conclusion is in perfect agreement with similar observations made in other species (Romanes, 1947), and above all with the result of previous investigations (Riese, 1942; 1945), according to which some mammals (bear, opossum) are born with their brains still completely deprived of myelin. The doctrine of cerebral localization is based on anatomical and physiological data obtained in the adult individual. If cere-

bral localization is understood to be an invariable correlation of finished nervous structures with corresponding nervous functions, the comparative neurology of the primate brain at the time of birth calls for a more flexible concept of cerebral localization.

SUMMARY

The myelogenesis of two chimpanzees at the time of birth was studied. After 204 days of gestation period the myelogenetic stage reached by the chimpanzee corresponds to that of a human embryo about 240 days old.

Myelogenesis is not in proportion to the gestation period.

After 12 days of extra-uterine life, the myelogenetic stage reached by the infant chimpanzee still limps behind that of a 16-day-old human infant.

A comparatively more mature motor behavior must be correlated with a comparatively less mature stage of myelination in the new-born chimpanzee.

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PELAGE OF THE PORCUPINE, *ERETHIZON DORSATUM DORSATUM*

By Donald S. Po-Chedley and Albert R. Shadle

The peculiar pelage of the North American porcupine makes it unique among mammals of the Western Hemisphere. Anderson and Rand (1943) place all northern American porcupines in one species, *Erethizon dorsatum*, containing five subspecies. Available information on the North American porcupine pelage is scant and widely scattered. Among the more important references to the pelage are Merriam's (1884) account of quill distribution, Seton's (1928) account of general information, Shadle's (1946, 1950) observations, Shadle, *et al.* (1946), and Taylor (1935) who discussed particularly the pelage of the western yellow-haired porcupine.

Methods and materials.—Twelve captive porcupines were observed in the laboratory, and the shedding of the hair was tested periodically for approximately two years. The molt was specifically investigated by measuring, at definite intervals, the relative changes in the follicular tension of specific hair types. This was accomplished by means of a hand-operated, ratchet type, spring scale which was tied to a clamp of known weight, and in turn the clamp was fixed to an individual hair. Tension was applied vertically until the hair was pulled free from the skin. A comparative record of changing follicular tensions, determined in grams, was maintained for over a year. Fifteen wild animals, which were captured at different seasons of the year, were also used for purposes of comparison.

In studying the replacement of spines in individual porcupines, areas on the back, and on the dorsal surface of the tail, were plucked of all coat hairs and quills. For purposes of identification, whole denuded skin areas, quill patches, or individual quill areas were indicated by an indelible pencil mark and subsequently the emerging quill growths were delineated with india ink. The plucked quills were measured and later compared with their replacements. Quills ranging in age from those that had just penetrated the skin surface, to the mature types, were mounted in clarite. This provided a serial demonstration depicting the gradual closure of the roots of the quills as they completed their growth.

In certain areas, the distal part of each quill was severed so that only the basal half remained attached to the skin, and these damaged quills were observed for evidences of replacement.

By means of a probe, tactile stimuli were applied to the guard hairs, quills, flank hairs, bristles, vibrissae, and circumvaginal hairs, to determine the possible functions of these structures. The conditions that prevailed during these tests, were of three types; (a) the animals were asleep or resting at the time of the test; (b) they were awake but were not permitted to see the operator or the probe; (c) they were permitted to watch the operator.

Measurements of quills from corresponding body regions of twelve mature porcupines were recorded for a comparative study of variations of quill length.

With certain minor modifications, the technique employed for the identification of hair scales was essentially that described by Hardy and Plitt (1940).

Preliminary observations of the hair scales were facilitated by the use of silver nitrate and potassium hydroxide (Po-Chedley, 1951). For the purpose of studying individual scales or "barbs," the quills were macerated in a 10 per cent sodium hydroxide solution.

General pelage features.—The North American porcupine is well covered with the fine, long or short coat hairs on all parts of the body except the flexor surfaces of the feet, the ventral tail area, the auditory meatus, the papillae mammae and adjacent areolar skin, the penis, and the nose.

Variations exist, for the lumbar section of the body may be either heavily clothed, sparsely covered, or almost completely devoid of fine coat hairs. Long coat hairs comprise a very dense cape-like growth in the dorsal and lateral neck, thorax, and anterior abdominal regions. Long, coarse, stiff, heavily pigmented, covering hairs are found, primarily, on the lateral surfaces of the legs, and to a lesser degree, on the cheeks, neck, and the flanks; they serve a tactile function.

The ventral surface of the body and the mesal surfaces of the four legs are covered with short, fine coat hairs, as well as a slightly longer, stiffer variety of coarse hair. The dorsal and lateral surfaces of the nose, cheeks, chin, pectoral area, and the regions covering the rectus abdominus muscle, show the densest growth of short coat hairs. The lateral surfaces of the snout possess vibrissae, which are also distributed on the supraorbital ridges and the cheeks.

An area extending approximately from the xiphoid process caudad to the lower abdominal quadrant and pubic regions, is usually more sparsely haired than the adjacent areas. The pubic hairs of mature male or female specimens are almost colorless, and sparsely distributed. The hairs associated with the labia minora are comparable to the pubic hairs in structural features, whereas, the hairs of the labia majora are similar to the coarser variety of ventral hair. These hairs of the labia majora are laterally distributed about the vaginal orifice and their free ends lean mesad, forming a sort of tactile, hairy canopy over the vaginal orifice.

The under surface of the tail is covered with short, very stiff bristles, which are securely fastened into the skin, whereas, the marginal bristles are markedly longer than the others. The ventral bristles are often considerably worn and broken, due to friction and pressure caused by the use of the tail for climbing, balancing, better contact, etc.

Guard hairs.—The guard hairs are distributed profusely throughout the dorsal and lateral thoracic region and along the flanks, legs and feet. Their anterior distribution may be more or less limited to the nape and the sides of the neck, but these hairs also occur sparsely to thickly scattered on the crown of the head. Their distribution in the skin is in the form of linear paths extending transversely across the body, with spaces ranging from 4 mm. to 15 mm. between hairs in the same row. The distance between the rows varies from 1.5 mm. to 5 mm., but it averages approximately 3 mm. from one row to the next.

The shaft features and color patterns of the guard hairs are variable. These hair types include long, slender, resilient hairs, as well as those that are shorter

and thicker shafted. Their most prevalent color combinations are: (a) entirely pigmented (either black or brown); (b) white tipped with pigmented shaft and base; (c) dark tipped with a white shaft and base. The completely white and banded forms, which are relatively few, may be found thinly scattered throughout the pelage.

The guard hairs are the longest of the hair types, and when fully grown, they extend well beyond the quills and the coat hairs. The average lengths in millimeters of the guard hairs, coat hairs and quills in the thoracic region were as follows: Guard hairs, 142; long coat hairs, 100; and quills, 74. Fifty hairs of each of three types, were collected from each one of 13 porcupines to determine the average lengths of hairs listed. The guard hairs and the coat hairs are present in the same rows, as distinguished from the quills which are in separate rows. In addition, the guard-coat hair association is in the form of a cluster, i.e., one guard hair with approximately 6–13 associated coat hairs.

The general guard hairs function specifically as protective tactile structures which keep the animal aware of conditions in its immediate surroundings. The guard hairs may vary in length up to five inches or longer, but regardless of length, they extend well beyond the ends of the general hair and quill coat.

Quills.—The exposed surfaces of the animal, viz., the crown of the head, cheeks, nape, the entire dorsal and lateral sides of the body proper, and the dorsal and lateral tail surfaces are thickly set with quills which vary in length, flexibility, color, shaft diameter, scaliness, and stiffness. Those most numerous and most widely distributed are the dichromatic quills, characterized by a pigmentation that may be localized at the distal end or may include the whole quill. Some totally white quills are found on most of the quilled areas, and some white quills of the dorsal region exhibit the extremes in length, slenderness, and weakness. The completely pigmented quills of the body area, are usually the shortest and heaviest of a group and have a relatively localized distribution, viz., they form an irregular band extending caudad along the mid-sagittal area of the back, mainly from the sacral region to the tip of the tail. There is a moderate distribution of small pigmented spines on the cheek surfaces.

The quills are well barbed or scaled on the distal area of the shaft (Fig. 1, Right), and barbs may extend from the tip along the quill shaft as much as two-thirds of the total length. The barbs generally are confined to the area of pigmentation except on the totally pigmented spines, which are usually barbed over the distal two-thirds of their length. The unpigmented quills are generally barbed only near their tips.

Quills grow in groups approximately 2 to 5 mm. apart and extend in transverse rows across the body, with a marked wavy path in the lumbar region. It is this marked variation in growth direction that produces the rosette formation peculiar to the humped lumbar and sacral regions.

Average quill lengths according to location are listed below. These figures were obtained by taking 20 quills of each area listed, from each of 20 porcupines; these quills of each area were then measured and the average determined for each area. Lengths of quills, in millimeters, from different regions were: Cheek,

11.1; tail, mesal area, 20.2; sacral, 22.1; forehead, 26.4; tail, lateral area, 29.4; lumbar, 41.2; and thoracic, 63.1.

The quills located on the sides of the body are much more flexible than the stiffer dorsal spines, which are usually completely pigmented. Other large hairs in this region, which resemble the quills in some gross features, may easily be confused with the true quills. The large hairs may be distinguished from quills by their origin in the coat hair tracts, their lack of barbs, and by the differences in the scales.

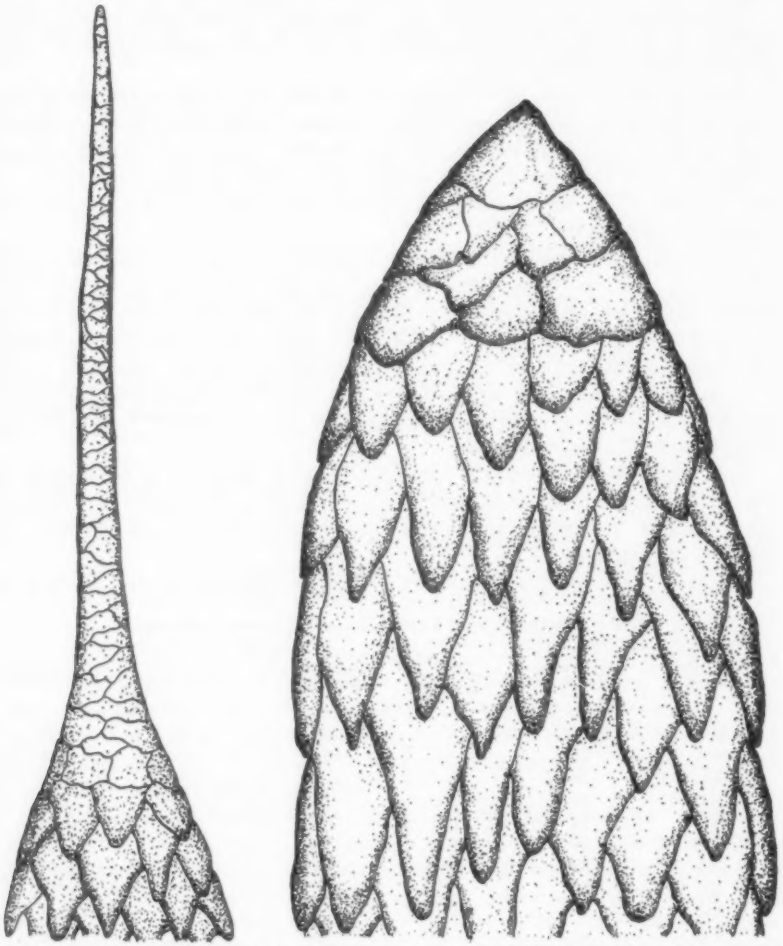

FIG. 1.—LEFT: Quill with a terminal filament. RIGHT: Quill tip showing scale arrangement.

Coloration.—The general coloration of *Erethizon dorsatum dorsatum* varies from black or brown, through gradations of grizzled gray. The basic coloration, due to the dark proximal parts of the coat and guard hairs, is softened by the white or yellowish tips of the long guard hairs. The dark tipped quills are more evident during the spring and summer after the old coat hairs have been shed, or while the new hairs are shorter. Since these brown or black quill tips overlap each other in an irregular fashion, the white quill shafts may also be seen, thus, lending a lighter shade to the general pelage color. This is particularly true directly after the spring molt, before the new coat hairs are well grown.

The underparts of the animals are comparable in basic color to the dorsal regions of the body, with the exception of the faintly pigmented pubic hairs and the dichromatic hair types.

Hair currents.—When the animals are relaxed, the hairs on the dorsal and ventral surfaces of the body are directed caudad. On the sides, the hair current extends obliquely ventro-caudad. On the anterior, lateral and median surfaces of the legs, the hairs are directed ventrad and ventro-caudad. The presence of hair whorls on the throat surface interrupts the general uniform ventral hair current toward the tail.

Hair tracts.—The porcupines appear completely covered by coat hairs, quills and guard hairs, but these different structures are borne only by certain areas of the skin, which are designated as the quill and coat hair tracts. This feature is evident on the dorsal regions of the body where the quill tracts are readily distinguished from the coat hair tracts. These different tracts range from 1 mm. to 4 mm. apart, and curve as they follow the somatic contours. The quill tracts terminate at the lower edges of the lateral surfaces, but the hair tracts continue directly onto the ventral region.

Quill replacement and growth.—Six animals, each denuded on the dorsum of the tail and lower back, were used for observations on the growth and replacement of quills. As a result of the replacement pattern, eleven quill clusters were followed to completion.

In Table 1, comparison of quills of different lengths shows that the growth

TABLE 1.—*Mature quill length compared to quill growth period*

No. quills measured	Average length in mm.	Removal to emergence Time in days	External growth time in days	Total growth time in days	Av. daily growth rate
200	15	22	29	51	0.52
250	22	33	29	62	0.76
250	23	19	46	65	0.50
300	24	16	76	88	0.32
300	24	190	72	262	0.33
200	34	130	68	198	0.50
300	35	10	68	78	0.51
300	35	42	31	73	1.10
300	38	10	72	82	0.53
300	44	34	58	92	0.76
300	54	10	91	101	0.59

rate of the shaft was approximately one-half millimeter per day, i.e., computing average lengths against external growth time intervals.

The interval between quill removal and later emergence of new replacement quills required varying periods of time, but quills followed a continuous progression to maturity once they had emerged from the skin. Nine of the test cases showed a relatively short time which ranged from 10 to 42 day intervals between removal and initial replacement, contrasted with the two long intervals of 130 and 190 days. Two animals requilled the denuded regions completely but the others grew quills in clusters or wave-like patterns so that the replacements appeared in patches. There were overlapping phases, in which new growths of quills were seen emerging, some were in intermediate stages of development, while still others were already approaching maturity. This overlapping occurred in spite of the fact that the dequilling of the area was all done at the same time. It was also noted that the spines which were attaining their maximum length and size, had initiated root closure, indicating cessation of the quill growth. This condition was recognized by the diminished bleeding or even lack of bleeding following quill removal and the marked reduction of the root opening. Complete closure of the root occurred after the quill had attained its maximum length.

Newly emerged quills possessed a distinctive structure in the form of a distal terminal, hair-like filament that appeared to be continuous with the barbed distal end of the quill. This end-piece was never observed on mature quills but was found only on the newly developing ones (Fig. 1, Left).

When the distal portions of the quills were clipped away leaving the bases of the quills, these bases were retained in the follicles for as much as a year or more. During that time, they were gradually replaced, but no signs of intensive or active growth of new spines were observed. This would suggest that even quite extensive quill damage has little or no effect on stimulating quill regeneration or replacement, unless the damaged quill is lost or removed.

Molt.—The coat hairs are usually shed more or less *en masse*, while the other hair forms are lost gradually, over a much longer period of time.

The nose, crown of the head, dorsum of the tail, and lastly, the thoracic region represent the general order of molting activity. There were no clear and distinct interruptions, but rather a blending or overlapping of the molting, from one region into another. The ventral surfaces of some individuals shed coat hairs rapidly and profusely, while others shed slowly. Animals that did not show a typical and gradual ventral molt, usually shed in patches over the pectoral, sternal, and median abdominal areas.

The times cited for the initiation of the molt and the subsequent completion of the winter pelage, refer to the animals conditioned to the laboratory. Other porcupines observed soon after being captured also showed variations in time of shedding and manner of hair replacement. Among Allegany State Park porcupines, five caught during early spring were in the characteristic winter pelage, four captured during mid-spring were just initiating their molt which was completed by late July or early August. Two animals captured in early

summer were in advanced stage of molt and completed their molt by midsummer. Four porcupines obtained in the fall were in full winter pelage, whereas the laboratory animals were still completing their new pelage. The laboratory animals showed still further variations, for some molted rapidly, others shed hairs uniformly but slowly from all parts of the body, and some showed a retarded condition in which some of the previous winter coat was retained, sometimes months beyond the normal molting season.

When fed, all of the porcupines were given the same foods, so that differences in kinds of foods supplied were eliminated as cause of atypical molting. The amounts of food taken and the foods chosen by the individual when feeding would vary to some extent. This quantitative and qualitative variation in foods taken by individuals may have influenced the individual molt, but since two to three animals generally occupied the same cage these differences in individual food intake could not be assessed.

The seasonal and room temperatures experienced were the same for the whole porcupine colony, and the individual temperature variations would to some extent depend upon the variations in thickness and length of the pelage. Some individuals produced rather sparse, light hair coats, while others had heavy, long hair coats.

The seasonal factor effect would seem to have been the same on the activity of the individual porcupines, for they were all subject to the same general light conditions during daylight, and also to the same artificial lights.

Through the year, there were changes in the follicular tension on the hair roots. Table 2 shows this condition in three types of hairs and indicates the weight, in grams, required to pull the individual hair types from the skin.

The regrowth of coat hairs was uniform and the entire hair-bearing regions of the skin appeared to be replenished evenly and simultaneously.

Hair scales.—The scales of the pelage components, with the exception of the spines, may be separated into two distinct categories, as represented by either the coat hairs or the coarser types. The shaft scales of all hair types are entirely imbricated, while the coat hairs possess also a series of coronal scales at the distal ends of the shafts.

The quills show a variety of scale forms. The scales of the extreme tip are a continuation of the scaled, terminal filament (Fig. 1, Left). These are followed

TABLE 2.—*Follicle tension**

Month	Coat hairs	Guard hairs	Quills
Jan.	63	178	146
Mar.	23	165	135
June	8	140	106
Aug.	8	138	110
Sept.	15	151	122
Nov.	29	161	131

* Average tension, shown in grams, required to withdraw specific hair types from the hair follicle, at certain periods of the year.

by a brief transition region of ovate imbricated scales which merge into the accuminate form or barbs. A polyhedral form with proximal edge closely adherent to the shaft is the dominant scale below the barbed region. Flattened scales with variable transverse dimensions are found on the greater part of the shaft, and they continue almost to the root. The root scales are characterized by their very compact crowded appearance.

The usual distribution of the barbs on any given quill shaft is confined largely to the area of pigmentation. The dichromatic quills are often barbed at the distal pigmented end of the shaft, but the black spines generally have functional barbs or barb-like scales over the greater length of the shaft. Quill scales of an albino porcupine corresponded to those of the pigmented spines of the typical animal. After maceration of the quill, the individual scales or barbs look like flat, dart-shaped units.

From the side, the roots of the hairs and the quills have a subcylindrical or conical appearance and are open or partially closed at the base, except the mature quills which have greatly reduced, closed roots. Between the bulbular root tip and the basal expansion of the shaft, there may be a constricted area composed of cuticular and cortical material containing scattered clusters of dry medullary cells.

General functions of porcupine hairs.—In general, the coat hairs and the spines of a porcupine are protective. The universal antero-posterior and dorso-ventral hair currents facilitate the passage of the animal through underbrush, and the denseness of the general pelage inhibits the penetration of rain and snow, effectively screens the burning rays of the sun, and in varying degrees conserves the body heat. When the animals are disturbed, they erect the pelage of the dorsal and lateral areas of the head, body, and tail, thus demonstrating arousal, fear, anger, and the attitude of defense.

Specific hair functions.—Specific functions of hairs depend upon their structure, their location on the body, and the manner in which the hairs are used.

Vibrissae are tactile receptors, serve as a means of protection, and are particularly important during the nocturnal wanderings of the porcupine, and wanderings in caves and other dark hiding places.

The long guard hairs enable the porcupine to maintain a peripheral tactile sensitivity up to 150 mm. or more, beyond the skin surface. They are excellent conductors of tactile stimuli, for even a gentle touch on their tips causes a prompt protective reaction, such as the erection of the quills.

The very sensitive, tactile, circumvaginal hairs near the vulva serve sexual functions. Their stimulation during precoital play increases sexual arousal, heightens the sex play, and functions as a guiding aid to facilitate entry of the intromittent organ into the vagina. Through the stimulation of these cirvumvaginal hairs, the female is able to determine the approximate position of the penis and to execute compensating movements which align the two organs in a successful intromission.

The under surface of the tail is covered by a dense growth of coarse bristles and their stiffness and toughness enable the porcupine to use the tail effectively

in climbing, balancing, etc. The tail is pressed against the bark of the tree or limb, and as the free ends of the stiff bristles press into the fissures and crevices of the bark, they help to support the animal and prevent it from slipping.

To a limited extent, the quills also may function as sensory receptors, but their primary function is defensive and offensive protection. When used offensively, the animal leans or rolls sidewise, or pushes backwards in an attempt to crowd and force the quills into the enemy. The quills on the tail are primarily defensive, for the tail functions most effectively as a flailing, spine-studded weapon the quills of which penetrate the skin and flesh of the attacker. They are more easily detached from the porcupine's skin than they are from the skin and flesh of the other animal, and hence, remain in the body of the enemy.

The finer, lighter quills and quill-like hairs on the sides, serve to protect the vulnerable belly which bears no quills. The belly region is further protected when the animal flexes itself so the quills of the shoulder, side and hip are brought into position to contact the threatening enemy.

Quill withdrawal.—The easy withdrawal of quills from the skin of the porcupine, is mainly due to structural peculiarities of these quills, i.e., (a) the scaled surface, (b) the nature of the root of the quill, and (c) the follicle tension against the root surface.

Each scale along the quill may serve as a small anchor to hold the spine in the tough skin or the tissue of the adversary. These scales also increase the penetrating power of the spine, for when the scales engage the muscle fibers of the enemy, the pull of the muscle action against the retrorse scales draws the quill further into the penetrated tissue (Shadle, 1947; Shadle and Po-Chedley, 1949).

Mature quills, like mature feathers, are dead structures, and the great reduction of the root surface and root size, gives the mature quill much less attachment surface within the follicle, and the reduced tension of the follicle upon this root surface is an important factor in the withdrawal of the quill from the porcupine.

The ease of withdrawal from the porcupine, the anchoring function of the scales of the quill, and the toughness of the skin of the other animal, cause the ready transfer of the quills from the porcupine to its victim.

Sensitivity during periods of rest and sleep.—Resting and sleeping porcupines are acutely sensitive to tactile stimulation of the guard hairs. Their typical response is a quick movement with a prompt erection of the spines so that the effective points of the quills are prominently exposed in all directions. In the case of porcupines in a deep sleep, a stronger stimulation is necessary to bring about this reaction. Resting animals, permitted to watch the operator, respond partially by raising the quills or by pulling the skin forward before they are touched, but when stimulated the usual complete flaring erection of the pelage results. The reactions of wild porcupines, only recently captured and not accustomed to being handled, were more spontaneous and more marked than those of the laboratory conditioned animals.

Discussion.—The hair types of Erethizontidae as defined by Burell and Ellis (1927), Taylor (1935), and Hardy (1942) do not include all of the hair types.

The systems devised by Toldt (1910) and Danforth (1925) approximate the pelage types of the porcupine, but do not provide a distinct niche for the quills, nor for hairs according to the scale forms. Because of the variety and singular characteristics of the scales, and because of the terminal hairlike filaments present on the new quills (Fig. 1, Left), it is believed that the porcupine quills should be considered a special type of hair. The other hair types may be differentiated by means of their gross structure.

The observed pattern of quill distribution of the porcupine does not particularly coincide with the theoretical primitive distribution pattern (Kingsley, 1912; Arey, 1947), for quill groups of varying numbers may be found in the linear rows of quills. This absence of definite hair groups may represent an advance beyond the older condition. The pelage of *Erethizon dorsatum dorsatum* definitely displays a high degree of specialization of hair forms.

This investigation indicates that "the ninety day growth period" referred to by Seton (1928) really applies only to quills that grow to approximately 40 to 45 mm. in length. Spines of greater or shorter lengths require correspondingly longer or shorter periods of time to grow to their complete length and size. Observing the follicular activity of the guinea pig, Dawson (1930) found the time involved in the growth of guinea pig hair to be directly related to the length of the completely grown hairs. This condition also applies to the growth of the porcupine quills. The observed wide range of time between plucking of the quills and the emergence from the skin of the new replacement quill suggests different degrees or rates of follicular activity.

Haddow *et al.* (1945) and Hale (1945) reported that only limited regions of depilated skin of the albino rat regained hair at any one time, and that the regrowth originated in waves, with the younger hairs on the advancing edge. Similar plucking tests on the Canadian porcupine sometimes resulted in a rather uniform regrowth of both quills and hair. In some cases, clusters of quills appeared in different regions of the depilated areas, but these clusters of quills also grew uniformly in size.

From the clipping and plucking of hairs of mice (Collins, 1918), the plucking of hairs from the guinea pig (Dawson, 1930), and the clipping and shaving of the pelts of mice (David, 1936) it has been concluded that only plucking hastened hair regrowth, and that clipping and shaving did not hasten the process. In porcupines, only plucking initiated the replacement of quills, whereas, clipping and breaking of spines were not effective in causing their replacement, and unless removed, such damaged quills usually were not replaced until the next normal molt.

The scaled appearance of animal hairs provides a means of identifying different kinds of hairs. Several scale delineation methods were tested and subsequently rejected. The Hardy (1940) technique provided a practical means for examining a series of whole hairs or quills quickly and in sufficiently large numbers to obtain accurate data from the sample. This method was especially valuable in the study of quill scales or barbs.

In the western yellow-haired porcupine, Taylor (1935) found that barbs "fade away" at the expanded shoulder of the spines, but in the eastern form this

applied only to quills with pigmentation of the extreme tip or to those totally unpigmented. Taylor also noted an air space in the western porcupine quills, but in the eastern porcupine, an air space was observed only in old and thoroughly dried quills.

The quills differ from other types of hair in gross appearance, by possessing several different scale patterns on the shaft, and possessing a terminal filament when the quill first emerges. This terminal filament suggests that the quills may be the result of the activity of a single follicle comparable to the development of contour feathers as described by Hyman (1947). Messer (1947) suggests another interpretation in saying, "In hedgehogs and porcupines numerous individual hairs are joined together to form the characteristic spines or quills."

Since this study leaves such problems unanswered, it is hoped that such questions will supply impetus for further experimentation.

SUMMARY

The pelage components of *Erethizon dorsatum dorsatum* consist of quills, sensory hairs (guard hairs, vibrissae, and circumvaginal hairs), long and short coat hairs, long and short coarse hairs, and stiff bristles. In general, hairs are arranged in linear paths with the quill rows separate from the rows of coat hairs. The quills distributed over the dorsal and lateral regions of the head, neck, body and tail vary in length, shaft diameter, and stiffness. There is no conclusive evidence of a basic grouping of quills or coat hairs according to a primitive mammalian pattern. The surface of the quills is characterized by a variety of scale forms as well as the retrorse scale arrangement on the distal portion of the shaft. The other hair forms exhibit only two distinguishing scale patterns, the imbricate and the coronal types. Newly erupted quills possess a hair-like, scaled filament which is continuous with the tip of the quill proper, but the filament is soon lost.

The daily growth rate is approximately the same for all types of quills. Lost quills are soon replaced, but damaged quills are replaced at the next molt. The coat hairs are shed and replaced *en masse* seasonally, as contrasted with the gradual and individual loss and replacement of quills and other hair types. The hair types have specific functions related to their structures, size, location, and orientation. The progressive change of follicular tension on the quill roots has a direct effect upon the molt, the withdrawal, and the loss of the quills.

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ADDITIONAL DATA ON THE BACULA OF NORTH AMERICAN BATS

By Philip H. Krutzsch and Terry A. Vaughan

Relatively few reports are available on the structure of the os penis (baculum) in the Chiroptera. Hamilton (1949) summarized much of the meager literature available and presented data (figures and descriptions) on the bacula of 14 species of North American vespertilionid bats.

We have been able to bring together a collection of bacula representing 12 additional species and subspecies of bats from North America. The bacula of small bats are delicate and tiny structures; therefore, in order to facilitate study and handling and to prevent damage and loss, the specimens were stained and mounted according to the method developed by White (1951).

All bacula preserved were from adult animals and were obtained, in most instances, from fresh specimens. A general orientation for descriptive facilitation in regard to the proximal, distal, dorsal and ventral aspects of the baculum was made; however, there was no attempt to determine the relationships between the bony and fleshy parts of the penis.

Most of the species described are known to us by a small sample and, therefore, the range of variation between individuals has not been ascertained. Small variations in linear size and in the shape of the bacula were noted, even though the specimens were obtained on the same day and at a single locality. Possibly these variations are due to difference in age although, according to our criteria (knobby metacarpal and phalangeal joints), all individuals were adult.

The value of the baculum as an aid in defining relationships and natural groupings among various North American mammals is amply documented (Burt, 1936; Howell, 1938; Burt and Barkalow, 1942; Wade and Gilbert, 1940; Hamilton, 1946; and Hamilton, 1949). Much of the material described by us is from closely related species of a single genus or from several subspecies of one species. In the case of closely related species the baculum can, in the absence of other clear cut distinguishing characteristics, serve as a criterion in judging relationships. The differences at the subspecific level are slight and seem to be of little systematic value.

Variations in the bacula of closely related species of bats are chiefly in shape, detail of outline, and gross size. In a series of subspecies representing one species the shape of the os penis is relatively similar. The dissimilarity of the bacula of *Myotis subulatus melanorhinus* and *Myotis subulatus leibii* (as figured by Hamilton, *op. cit.:* 98), therefore, might suggest a more distant relationship than heretofore considered.

Hamilton (*op. cit.:* 101) pointed out that close affinity of certain genera is indicated by the os penis (e.g., *Lasiurus borealis* and *Dasypterus*; *Myotis* and *Pizonyx*) and that a very great dissimlarity of the bacula, between species of a single genus, might suggest subgeneric or generic differences (e.g., *Pipistrellus hesperus* and *Pipistrellus subflavus*).

From our observations on several series of superficially similar species, we find that the well marked and consistant differences in the bacula found reinforce the more subtle cranial and external characters of the species (e.g., *Myotis*

yumanensis vs. *M. lucifugus*; *M. californicus* vs. *M. subulatus melanorhinus*). This was not so in the case of *Antrozous bunkeri* and *A. pallidus* where the bacula of the two species were found to be nearly identical in size and shape. *Antrozous bunkeri* was first described by Hibbard (1934) who considered it a distinct species owing to its geographic isolation from and lack of morphological integration with, the neighboring *Antrozous pallidus*. Hibbard thought that *bunkeri* showed a closer relationship to *A. pallidus pacificus* than to *A. p. pallidus* even though *pallidus* has a geographical distribution closer to that of *bunkeri* than does *pacificus*. We are in agreement with him on this point and find it most difficult to select individuals of *A. p. pacificus* from a mixed series of *A. bunkeri* (topotypes) and *A. p. pacificus* (obtained in San Diego, California). The fact that the cranial and pelage differences existing between *A. pallidus* (either *pacificus* or *pallidus*) and *A. bunkeri* are at best only average ones and that the bacula of all three are quite similar, has led us to propose that *A. bunkeri* and *A. pallidus* be considered conspecific and that *bunkeri* be arranged as a subspecies of the prior *Antrozous pallidus*.

We were able to obtain bacula from all but one of the species of bats we dissected. The California leaf-nosed bat (*Macrotus californicus*) apparently lacks an os penis as none was found in any of the 16 individuals we examined.

The following descriptions of the bacula of the species studied are intended to supplement the drawings presented (Fig. 1).

Myotis californicus stephensi (Fig. 1 A-A′).—The penis bone of this bat is gently pointed distally and broadly rounded proximally. In lateral aspect the bone has a rounded knot-like ventral projection and forms a smooth longitudinal arc, convex dorsally. The structure is small, averaging 0.76 mm. (0.78 mm.–0.72 mm.) in length in the six individuals studied.

Myotis subulatus melanorhinus (Fig. 1 B-B′).—The baculum of this subspecies differs strongly from that of *Myotis subulatus leibii*. The distal and proximal ends are roundly pointed and there is a ventral projection. The ventral surface is concave. The dorsal surface in lateral view is smoothly curved with an indentation at the tip. The structure averages 0.84 mm. (0.85 mm.–0.83 mm.) in length in the two individuals studied.

Myotis thysanodes thysanodes (Fig. 1 C-C′).—The baculum of this subspecies in the two individuals studied is a small, dumbbell-shaped structure averaging 0.77 mm. (0.78 mm.–0.76 mm.) in length. The ventral surface is grooved lengthwise, presumably to allow passage of the urethra.

Myotis velifer velifer (Fig. 1 D-D′).—In lateral view the distal and basal portions of the dorsum of the baculum are widened and the center is grooved lengthwise. From the ventral aspect the bone appears somewhat cylindrical but it is broadened basally and bluntly rounded at the tip. The ventral surface is grooved. The bone in seven specimens averaged 1.0 mm. (1.3 mm.–0.93 mm.) in length.

Myotis velifer incautus (Fig. 1 E-E′).—The baculum of this subspecies is almost identical to that of *M. v. velifer* but when viewed from the lateral aspect the tip and base are slightly more truncate and the middorsal concavity longer. The single specimen available measured 1.2 mm. in length.

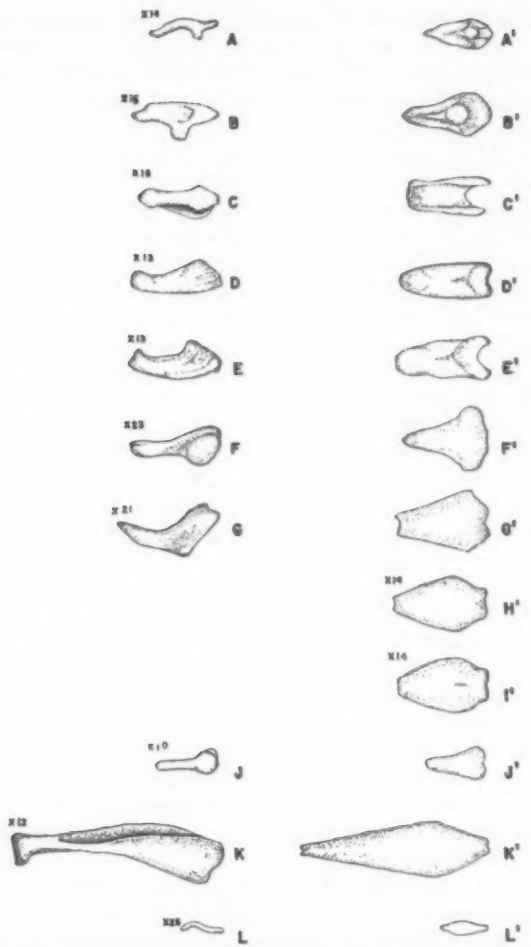

FIG. 1.—Representative figures of the bacula of the bats: A-A', *Myotis californicus stephensi*; B-B', *Myotis subulatus melanorhinus*; C-C', *Myotis thysanodes thysanodes*; D-D', *Myotis velifer velifer*; E-E', *Myotis velifer incautus*; F-F', *Myotis yumanensis sociabilis*; G-G', *Antrozous pallidus pallidus*; H', *Antrozous pallidus pacificus*; I', *Antrozous pallidus bunkeri*; J-J', *Corynorhinus rafinesquii pallescens*; K-K', *Pipistrellus hesperus merriami*; L-L', *Tadarida mexicana*. All figures on the left are lateral views with dorsal side upward (except J and K that are with ventral side upward). The figures on the right are in dorsal aspect (except A', B', and C', which are in ventral aspect). The magnification for each pair of figures is indicated on the lateral view.

Myotis yumanensis sociabilis (Fig. 1 F-F′).—The baculum is triangular in shape when viewed from the dorsal aspect. In lateral view the shaft is rounded, within a distinct tip, and the base is enlarged to a knob. Ventrally the os penis is grooved. The average length of the bone for the two individuals studied is 0.60 mm. (0.65 mm.–0.55 mm.).

Antrozous pallidus pallidus (Fig. 1 G-G′).—In lateral aspect the bone has an angular, almost saddle-like, appearance with the tip pointed and the base truncate. The bone is grooved ventrally and weakly convex or flattened dorsally. When viewed dorsally the bone is wedge-shaped, widening from a broad base to reach its greatest width at the mid-point or before and then gradually tapering to a truncate tip, usually slightly narrower than the base. This basic pattern of the baculum is characteristic for all the subspecies of *Antrozous pallidus* we have studied. The average length of the bone for the two *A. p. pallidus* studied, was 1.0 mm. (1.1 mm.–0.99 mm.).

Antrozous pallidus pacificus (Fig. 1 H′).—In general the shape of the os penis of this bat is like that described for the baculum of *A. p. pallidus*; however, the bone averaged slightly longer, 1.1 mm. (1.2 mm.–0.98 mm.), in the seven individuals studied. When viewed dorsally the bone from some individuals is perhaps less angular (i.e., more rounded) than is the case in the other subspecies of *Antrozous pallidus*.

Antrozous pallidus bunkeri (Fig. 1 I′).—The baculum of this bat is shaped, in general, like the bacula of the other subspecies of *Antrozous pallidus*. The average length of the bone of the two individuals studied was 1.09 mm. (1.10 mm.–1.08 mm.) closely comparable to the length of the os penis of *A. p. pacificus* and slightly longer than the baculum of *A. p. pallidus*.

Corynorhinus rafinesquii pallescens (Fig. 1 J-J′).—The baculum of this bat is similar to that of *Corynorhinus macrotis*, as figured by Hamilton (*loc. cit.*: Pl. 1, Figs. j and k) but is less pointed distally, saddle-shaped and not so strongly rounded dorsally. The ventral surface is grooved but not so deeply as in the baculum of *C. macrotis*. The average length of the bone for the four individuals studied was 0.79 mm. (0.84 mm.–0.76).

Pipistrellus hesperus merriami (Fig. 1 K-K′).—The bacula obtained from specimens of this subspecies lacked the notching of the proximal end seen in Hamilton's (*loc. cit.*: Pl. 1, Fig. f) material. In other aspects our specimens were closely similar. The average length of the bone for the eight individuals studied was 2.1 mm. (2.2 mm.–2.0 mm.).

Tadarida mexicana mexicana (Fig. 1 L-L′).—This bat has an extremely small baculum. In lateral aspect the bone is bent step-like and, when viewed dorsally, it is widened medially and narrow both proximally and distally. The small size of this structure (0.30 mm. in length) may account for our failure to locate the os penis in nine of the ten *T. mexicana* we dissected.

SUMMARY

Several superficially similar species of bats were found to have markedly different bacula. The bacula of subspecies of a single species are usually very similar in general shape but may differ in linear size.

The bacula of the bats *Antrozous bunkeri*, *Antrozous pallidus pallidus* and *Antrozous pallidus pacificus* were nearly identical. The similarity of the bacula of these bats and the small average differences in external and cranial characters led us to consider *A. bunkeri* only subspecifically distinct from the prior *A. pallidus*.

Descriptions and figures of the bacula of 12 species and subspecies of bats (mostly from western North America) are presented. One species of bat (*Macrotis californicus*), which we dissected, apparently does not possess an os penis.

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NOTES ON MAMMALS OF PERRY COUNTY, OHIO

By Brice Metzger

Perry County, which lies within the Appalachian Plateau, is located in southeastern Ohio. Field work was done in the west-central portion of the county. Most of this area lies between the southern limits of the Wisconsin and Illinoian glaciation, the boundaries of which are about twenty miles apart in the county. Here the soil is predominantly clay-sandstone, with outcroppings of shale and coal appearing in the smaller stream cuts. Rush Creek, the main drainage outlet of the area, is tributary to the Hocking River.

The region studied is composed of hills that rise 100 to 200 feet from valley floors having a mean elevation of 820 feet. Both beech-maple and oak-hickory forest types are present, the beech and oak predominating. During recent years, a few pine plantings have been made. The major land use is grassland farming, with a few clay and coal industries.

Field observations and collecting were carried on during the years 1948–1953. The majority of field work was accomplished while I was engaged as a farmhand during the summers of 1952–1953.

Since so few notes have been published concerning the mammals of southeastern Ohio, it seems advisable to make the following available. All measurements are in millimeters.

ACCOUNTS OF SPECIES

Didelphis marsupialis virginiana Kerr. Opossum.—The opossum was abundant at all times. An increase in their number was seen in the fall of 1950; but the following fall it was somewhat lower. The hard winter of 1950–1951 may have been the cause of this. Many were seen killed on the highways throughout the year, especially during the spring. The few opossums taken each year by hunters are usually taken incidental to coon-hunting, as they brought only $.30 (1952).

On December 28, 1951, a female was captured whose ears and tail were badly frostbitten. This specimen was kept in captivity until February 3, 1952, when she was tagged and released.

Three skulls were picked up from road kills. Another was taken from the crotch of a tree where it had hung for several years. It is a large skull, having a condylobasalar length of 125. A young male, taken December 11, 1948, had these measurements: length, 398; tail, 152.

Scalopus aquaticus machrinus Rafinesque. Prairie mole.—These moles, by the number of tunnels seen, seemed very common. Tunnelings were never located in the woods, but were most frequently met with in pastures, cornfields, and well drained bottom lands. During the summer months their characteristic mounds were uncommon, but became common in the spring. Where corn and wheat were growing side by side, as in strip-farming, the moles' tunnels were restricted to the more root-free soil of the corn.

A live specimen were taken 1 mi. S. Junction City on August 4, 1952. It was kept in captivity for six days. Measurements of this adult are: length, 165; tail, 31; hind foot, 20.

Blarina brevicauda kirtlandi Bole and Moulthrop. Short-tailed shrew.—These were the second most abundant mammals trapped, exceeded only by the white-footed mouse. A specimen was taken almost every trapping night. Ordinary mouse traps, baited with corn meal and rolled oats, were used. This bait was readily taken. The trap was placed in a depression at a right angle to the runway; the treadle being in the center of the runway.

On February 4, 1951, after a twelve-inch snowfall, a shrew was seen running across a road. Tunneling in the snow was a common sight. Shrews were taken most frequently in the woods. One was taken by hand in a freshly mowed hay field 200 yards from the nearest woods.

Eight specimens were kept, including two brought in by cats. Average measurements of seven adults are: length, 109.5 (105–115); tail, 20.5 (18–24); hind foot, 13.5 (12–15).

Myotis.—About one hundred bats were seen on July 28, 1952 entering an old house 2 mi. W. New Lexington. Their size and erratic flight left little doubt that they belonged to this genus; most probably *Myotis lucifugus lucifugus*.

Pipistrellus subflavus subflavus Cuvier. Pipistrelle.—These bats are probably common throughout the area. There are several caves 10 mi. SE. of the area, but no visits were made to them. An immature specimen was collected on July 13, 1953, while flying about a group of farm buildings.

Eptesicus fuscus fuscus Beauvois. Big brown bat.—This species was taken only once. Undoubtedly they are quite common; especially around the towns. Several bats were seen at various times that may have belonged to this genus, but positive identification was impossible.

The one specimen collected was taken 1 mi. S. Junction City, on September 11, 1951, by Mr. William Metzger. The measurements of this male are: length, 100; tail, 44; hind foot, 9; ear, 14; tragus, 8; forearm, 45; wingspan, 308.

Lasiurus borealis borealis Müller. Red Bat.—This bat was very abundant. It was readily identified by its characteristic flight, which one soon learns to recognize.

On several occasions, in the evenings, I have seen many of these bats flitting over the woods in the distance. Four were seen from time to time over a three-acre woodlot. Another woodlot, six acres in size, often had as many as four of these bats flying about in the evenings of the summer. These observations and others have given me the impression that these bats are very numerous in the county.

Four specimens were collected at several localities south of Junction City. None were observed hanging from trees. Average of three males: length, 91.6 (88–98); tail, 36 (33–41); hindfoot, 6.8 (6–7); ear, 9.6 (9–10); tragus, 4.6 (4–5); forearm, 37.6 (35–40). One female: length, 110; tail, 47; hind foot, 7; tragus, 5; forearm, 39; wingspan, 301.

Procyon lotor lotor Linnaeus. Raccoon.—This species is very common in the county and many tracks were seen along the stream banks of the area. They are sought with great enthusiasm by night hunters, since dark pelts recently sold for $1.25 each. As much as $14.00 each was paid for top grade coon hides from this area during 1927–1929.

Raccoons were often observed abroad in the early afternoon. One seen on August 29, 1950, was catching small fish trapped in a pool of an intermittent stream. A tagged specimen from a state game farm in Hopewell Township, was taken 15 mi. south of the game farm on October 29, 1949. Inquiry showed that this female was released on August 30, 1949.

An adult male taken on November 15, 1950, had these measurements: length, 678; tail, 197; hind foot, 97. Seven skulls were collected from hunters. All were taken in the immediate area southwest of Junction City.

Mustela rixosa allegheniensis Rhoads. Least weasel.—This weasel appeared to be rare, but was probably present in greater numbers than observations indicated. The single specimen, taken in November, caused much excitement among the inhabitants of the region who had never seen such an animal. A few thought it a young weasel, but could not explain such a condition at this time of year.

This individual was cornered by dogs in a field of corn stubble and was captured alive. The collector, Mr. L. E. Metzger, kept it in captivity for two weeks. It died on December 2, 1950, and was preserved. The measurements of this adult female are: length, 183; tail, 27; hind foot, 20. This specimen was not white but was in the summer coat.

Mustela vison mink Peale and Beauvois. Mink.—Mink were uncommon. Trapping and polution of streams by coal industries have caused their general decrease during the last decade. One mink, trapped in November, 1948, sold for $14.00.

Mephitis mephitis nigra Peale and Beauvois. Striped skunk.—Skunks were abundant

everywhere. According to information gathered from hunters, an epidemic killed many of the skunks in the early 1940's. Since then, they have gradually increased in number until 1949 when they were again common. Many were seen prowling about in meadows and fields in the evenings. One seen on July 27, 1951, was abroad at 3:00 PM after a short rain.

One skull was picked up on Wyble's Nob, 3 mi. W. New Lexington.

Vulpes fulva fulva Desmarest. Red fox.—Red foxes were abundant from time to time but were usually thinned out by hunters. Recently, a bounty of $3.00 has been placed on foxes. Information from experienced hunters shows that red foxes travel over a larger range than gray fox in the same period of time. One was known to range within an oval 3.5 miles in length.

The farmers of the area have employed a very effective device to keep foxes away from roosting chickens. Since much of the area is fenced with electric fences, a fluorescent tube with a wire soldered to each terminal, is hung by one wire from the fence while the other wire is grounded by sticking it into the ground. The constant flashing of the tube is very effective in keeping foxes away.

A skull was taken on January 20, 1952 and a skeleton was secured on January 31, 1953.

Urocyon cinereoargenteus cinereoargenteus Schreber. Gray fox.—Gray foxes were also abundant but were restricted more to the wooded areas. Two skulls were collected 2 mi. S. Junction City, on December 28, 1952.

Marmota monax monax Linnaeus. Woodchuck.—These animals were very common. During the summer of 1953 three were taken from a five-acre field of alfalfa. A lactating female was killed by dogs on May 26, 1951.

Two skins and skulls were collected. The skins, both taken in August, had these measurements: length, 600, 580; tail, 122, 150; hind foot, 80, —; ear, 29, 29.

Tamias striatus ohionensis Bole and Moulthrop. Ohio chipmunk.—Chipmunks were very common and most commonly found in open woods. Practically all burrows seen were located in hillsides and banks. Chipmunks were easily trapped in rat traps baited with kernels of corn. On several occasions their cheek pouches contained green buds and many kinds of seeds. None of these were identified.

Most chipmunks were in hibernation by the end of October but one was seen on November 24, 1950, after a three-inch snowfall.

Ten specimens were collected; all between May and October. Average measurements of four males: length, 231 (225–238); tail, 78.3 (70–88); hind foot, 34 (33–36); ear, 16.8 (16–17). Average of three females: length, 232 (225–251); tail, 85.3 (83–88); hind foot, 32.3 (29–34); ear, 17.8 (17–18).

Sciurus carolinensis carolinensis Gmelin. Gray squirrel.—These squirrels were common throughout the country. As many hollow trees are present, they are utilized by squirrels in winter. Leaf nests are used in the summer. Only one leaf nest, in use during the winter, was seen. A large red oak that contained the nest was cut during logging operations in December, 1952. This nest was about twelve inches in diameter and was held in place by several grape vines. The inside was lined with green, dry, oak leaves.

An albino male was collected by Mr. L. E. Metzger in November, 1951. This was the first albino that any of the local inhabitants had seen.

Sciurus niger rufiventer Geoffroy. Fox squirrel.—This species was never common and seemed to be restricted to local populations. A small population was located about 2 mi. NE. Crossenville but no specimens were collected. Two young, covered with fine hair, were found in a hollow tree on August 4, 1951.

A specimen shot on September 18, 1950 measured: length 555; tail, 260; hind foot, 66.

Glaucomys volans volans Linnaeus. Southern flying squirrel.—These squirrels were probably much more numerous than field observations showed. Only two were seen. These were routed from woodpecker holes while I was searching for white-footed mice. The first was in a hole about five feet from the ground. The other was routed from a hollow, fifteen feet from the ground in a dead elm snag, in the spring of 1951. Neither of these squirrels were captured. The nest, in which the latter was found, was composed of four layers of material.

On the bottom were wood chips, used by a woodpecker for its nesting material. On top of this were ten cherry pits and much mouse excrement. The third layer was composed of small sticks and horsehair. The top layer, in which the squirrel was found, was made of small bird feathers and strands of wool from a nearby sheep herd.

Hunters told me that they often see these squirrels while night hunting. A neighbor told me that he had seen at least seven of these squirrels together in a hollow snag. This snag and the surrounding area was visited in November, 1952, and all hollow snags and woodpecker holes were investigated, but no squirrels were found.

Peromyscus leucopus noveboracensis Fischer. White-footed mouse.—These mice were the most abundant mammals of the area. Trapping records indicate that they were just as common around farm buildings as the house mouse. Specimens were taken in all woodland habitats; a few were taken in open areas.

Several were captured alive in woodpecker holes. Two nests were located on April 1, 1951, in the bottom lands extending west of Junction City. The first nest was four feet above the ground in the cavity of a dead willow. It held one mouse but it was not taken. The other nest was in the hole of a river birch about five feet above the ground and contained a female with four young. They were very young and had no hair. This litter was kept in captivity for one month. Their eyes opened on April 12 and they were weaned around April 20.

On September 2, 1951, a nest under a large board near a corn crib contained an adult female. When revisited the following day the female was observed with five young that were apparently born during the night. This litter was also placed in captivity. The eyes of the young opened September 19. Due to unknown causes the female ate four of her young; the last being eaten on September 23.

Another nest was observed under a pile of trash during the early part of May, 1952. An unusual nest was placed at the bottom of a six inch casing which stuck three feet out of the ground.

Twenty-one specimens were collected. Average measurements of fifteen males: length, 155 (133–175), tail, 70.6 (59–83); hind foot, 20.6 (19–21); ear, 15.2 (14–16). Average measurements of six females: length, 163.3 (148—175); tail, 74.5 (64–83); hind foot, 20.3 (19–21); ear, 15.7 (15–18).

Ondatra zibethica zibethica Linnaeus. Muskrat.—This species was common but was seldom seen. Houses and tracks were common and a few road kills were seen. The characteristic houses of mud and sedges were present in the few marshes of the area, but elsewhere the bank den was utilized.

A small population existed along Dry Run in 1950–1951, but were trapped out. The only specimen obtained was a crushed skull from an individual brought in by dogs in August, 1953.

Microtus pennsylvanicus pennsylvanicus Ord. Meadow Mouse.—Field observations showed this mouse to be locally distributed within the area as pointed out by Bole and Moulthrop (Sci. Publ. Cleveland Mus. Nat. Hist., 5: 83–181, 1942) in their treatment of this species. The few runways located showed no sign of recent use. A few owl pellets collected from the area were composed almost entirely of the remains of this mouse.

An adult male, collected on December 23, 1950, was the only specimen taken.

Mus musculus musculus Linnaeus. House mouse.—House mice were very common around buildings, grainaries, etc. One pair was observed around a temporary corn crib, located about one hundred yards from a group of farm buildings. Their nest, located under a sheet of roofing, was composed of dry leaves; whereas the nests of several white-footed mice that nested in the same corn crib during different times, were constructed of dried grass only.

Three specimens were collected. Their respective measurements are: length, 145, 157, 174; tail, 64.5, 68, 86; hind foot, 18.5, 17, 19; ear, 14, 13, 15.

Rattus norvegicus Berkenhout. Norway rat.—Very common around buildings. In the fall of the year these rats move into temporary corn cribs that are constructed in open fields. As many as seven rats were killed while one of these corn cribs were being torn down. Old timers tell me that years ago (around 1900), these rats lived in the woods during the summer but moved into the farm buildings when cold weather commenced. Two skulls were collected.

Zapus hudsonius rafinesquei Bole and Moulthrop. Meadow jumping mouse.—This mouse was uncommon. They were first noted in the early 1940's, in a field of soy beans. In the spring, a nest of this mouse was found in a pile of lime near this field. The nest was near the center of the pile in a spherical cavity about five inches in diameter. It contained one adult and five half-grown young which were dead.

An adult female was trapped in a small swale located in the center of an old field of timothy and brome grass. This specimen was taken 2 mi. SW. Junction City on August 1, 1952. Its measurements are: length, 215; tail, 128; hind foot, 30; ear, 12. This specimen was deposited in the Ohio State Museum (No. 1704).

Another was seen the same day about one half mile south of the above locality, also in a field of timothy and brome grass. A female was captured alive on August 25, 1952, ½ mi. S. Junction City, by Mr. William Metzger. It weighed 18 grams and was kept until March 22, 1953.

This mouse swam readily when placed in water, the hind legs being the only appendages used. The fore feet were held parallel along the sides of the body. This method of locomotion was also used when swiming under water.

On February 22, 1953 I placed the mouse in a refrigerator (40°F) to see if hibernation could be induced. The next morning it was in a state of hibernation and at this time weighed 13.8 grams. When placed in a room (70°F), it came out of hibernation in six hours. This specimen was made into a study skin. Its measurements are: length, 162; tail, 81; hind foot, 30; ear, 12; weight, 14.5 grams.

A male collected 3 mi. SW. Junction City, May 30, 1953, measured: length, 187; tail, 114; hind foot, 29; ear, 12.

Sylvilagus floridanus mearnsii Allen. Cottontail rabbit.—Rabbits were common, but a decrease in their number was noted in 1951, the year following the big snow.

Introduction of rabbits from Missouri and Kansas by sportmen's clubs has occurred from time to time. These introduced species are darker and smaller in size than the native stock. Three skulls were collected.

Odocoileus virginianus virginianus Boddaert. White-tailed deer.—Prior to 1948, no deer were seen within the area, but since then they have become fairly common and are increasing in number. A doe, with two spotted fawns, was seen along the western boundary of Perry County, 3½ mi. W. Junction City, on September 27, 1953. On the evening of November 21, 1953 four deer were seen in a corn field 2½ mi. W. Junction City.

1001 S. Cassingham Road, Bexley, Ohio. *Received May 17, 1954.*

THE STATUS OF THE SPECIES OF THE *BRASILIENSIS* GROUP OF THE GENUS *TADARIDA*

By Albert Schwartz

Shamel (Proc. U. S. Nat. Mus., 78 (19): 1–27, 1931) accorded specific rank to the nine forms comprising the *brasiliensis* group (as understood by him) of the genus *Tadarida*. Of the nine forms, five (*murina*, *antillularum*, *muscula*, *costanzae*, *bahamensis*) are limited to various islands of the West Indies. The remaining four forms occur serially and apparently allopatrically from Chile, Paraguay, and Argentina (*brasiliensis*), through Central America (*intermedia*), to México and the western United States (*mexicana*) and eastern North America (*cynocephala*).

The four mainland forms are customarily now regarded as full species. In no case have specimens been designated, either by Shamel or by subsequent writers, as being intermediates or intergrades between these species. As presently understood, there are gaps recorded between the range of *cynocephala* in eastern Louisiana and *mexicana* in central Texas. Likewise, between *brasiliensis* in Costa Rica and *intermedia* in Guatemala, specimens are lacking. Although such gaps in the range of these molossids may occur, it is quite possible that they are due to the lack of sufficient collecting in the intervening areas, and not to the absence of the bats themselves.

In the opinion of the writer, the nine named forms of the *brasiliensis* group may more properly be designated as races of a single species, rather than as nine separate species. Differences between the species as now recognised are such as are customarily held to separate races. Structural differences are absent, and those differences which do exist, such as color of pelage and skull measurements, are of a subspecific degree. Examination of 255 skins and skulls and 99 alcoholic specimens of members of the *brasiliensis* group, representing all the known forms, reveals that no trenchant differences of specific character exist between the named forms.

Shamel (*op. cit.*: 8) differentiates *cynocephala* from *mexicana* by the fact that the greatest length of the skull of *cynocephala* is always 17.0 mm. or greater, whereas the same measurement in *mexicana* is usually less than 17.0 mm. Measurements of skulls of 67 males and 77 females of *cynocephala* from Marco Island, Collier County, Florida, indicate that this supposed difference between *mexicana* and *cynocephala* is not so clearly defined as Shamel indicates. Greatest length of skull in this series of 144 specimens of *cynocephala* averages—*not* exceeds in all cases—17.0 mm., with an observed range of 16.2 mm. to 17.7 mm. Females average smaller than males (16.8 mm. in females, 17.2 mm. in males). Measurements of greatest length of skull in a series of nine male and four female *mexicana* from Pátzcuaro, Michoacán, México, give an average of 16.6 mm., with an observed range of 16.3 mm. to 17.3 mm. Again, females average smaller than males (16.5 mm. in females, 16.8 mm. in males). Thus, there is a clearly demonstrable overlap in measurements of greatest length of skull of *mexicana* and *cynocephala*. Skulls of a series of nine male *mexicana*

from Ft. Davis, Jeff Davis County, Texas, average 16.9 mm. (16.5–17.4) in greatest length, again an overlap between *mexicana* and *cynocephala*. Comparison of these data with measurements of a series of *cynocephala* from Gainesville, Alachua County, Florida, and Baton Rouge, East Baton Rouge Parish, Louisiana, shows the same situation: the limit of 17.0 mm. as a measurement of greatest length of skull does not separate *mexicana* and *cynocephala* as indicated by Shamel.

Other cranial measurements taken (zygomatic breadth, interorbital breadth, breadth of braincase, length of maxillary tooth row, breadth of rostrum at M^2) show the same degree of overlap in these two forms.

Comparison of similar measurements of *intermedia* from the Valley of Comitán, Chiapas, México, and Chimaltenango, Guatemala, to those of *brasiliensis* from various localities in South America (Peru, Paraguay, Brazil, Argentina) indicates that an overlap in all measurements taken occurs, although not to such a marked degree as in the case of *mexicana* and *cynocephala*. Specimens from the area between Guatemala and Costa Rica, the northernmost record for *brasiliensis*, might show more overlap in these characters.

Differences between *mexicana* and *intermedia* are of the same degree as those mentioned above. There is again the overlap of cranial measurements. As Shamel states, *intermedia* is intermediate between the ranges of *mexicana* and *brasiliensis*, but the characters of this form are not intermediate between those of the larger forms to the north and south.

In summary, the four forms of the *brasiliensis* group on the mainland of North and South America seem to indicate a chain of closely related, allopatric forms, the characters of which are of such a degree as to indicate that these species should more properly be regarded as races of a single species. This opinion is held in spite of the absence of intergrades, or even of specimens from areas which separate the ranges of these forms as at present defined, and because of the overlap of measurements of cranial characters and coloration which define the forms.

The five West Indian forms present much the same situation. In all these "species", the skull differences are average differences, and in no case is there an absolute difference between these island forms. If degree of difference of insular forms as compared with mainland forms is employed as a criterion, it is obvious that these island forms should be regarded as subspecies of the mainland species. The degree of difference between the insular forms is actually less than the differences between two adjacent mainland forms. Comparison of the measurements of greatest length of skull of *muscula* and *murina*, for example, shows that the extremes are identical, although the means differ. Similar differences occur in the other skull measurements. Allen (Bul. Mus. Comp. Zool., 54 (6): 244–245, 1911) regarded the three West Indian forms then recognised (*musculus, bahamensis, antillularum*) as races of *Nyctinomus brasiliensis*.

Miller (Proc. U. S. Nat. Mus., 27: 339, 1904), writing of *Nyctinomus musculus* (= *Tadarida muscula*) in Cuba, states: "A further peculiarity of the Cuban animal, apparently shared by all the West Indian members of the group, is the

minute size and rudimentary structure of the first upper premolar. In the continental species this tooth is well developed and provided with a distinct cingulum, while in the insular forms it is a mere terete spicule." Examination of fourteen skulls representing the five Antillean forms indicates that such is not the case. PM^1 is well developed and cingulate; it is small in size but no more so than it is required to be because of the small size of the skull. In three specimens of *murina* from Jamaica, PM^1 shows its greatest reduction. If this character were constant, it might form a basis for differentiating the island forms from these occurring on the mainland. On the basis of even such limited material, this appears not to be the case.

Thus it seems that assigning subspecific rank to the nine forms of the *T. brasiliensis* group of Shamel reveals the relationships of these forms to a better degree. No structural differences distinguish the mainland "species" from each other, nor from the West Indian forms, nor these latter from each other. Clearly, these forms are closely related, and differ from Shamel's *macrotis* group. It is here proposed, on the basis of the evidence mentioned above, that these nine forms be regarded as races of *Tadarida brasiliensis*, as follows:

Tadarida brasiliensis brasiliensis (I. Geoffroy)
Tadarida brasiliensis murina (Gray)
Tadarida brasiliensis cynocephala (LeConte)
Tadarida brasiliensis muscula (Gundlach)
Tadarida brasiliensis mexicana (Saussure)
Tadarida brasiliensis antillularum (Miller)
Tadarida brasiliensis bahamensis (Rehn)
Tadarida brasiliensis intermedia Shamel
Tadarida brasiliensis costanzae Shamel

I wish to acknowledge the courtesy extended me in the loan of specimens by Colin C. Sanborn (Chicago Natural History Museum), Miss Viola S. Schantz (U. S. Fish and Wildlife Service), and David H. Johnson (U. S. National Museum). Several pertinent discussions with Luis de la Torre concerning the status of these forms aided in forming my ideas, and I thank him for these discussions as well as for taking certain skull measurements of specimens from Paraguay and Brazil while in Washington.

SPECIMENS EXAMINED

Tadarida b. brasiliensis: **Argentina:** Río Negro, Chimpay, 3; Tucuman, Concepción, 1. **Chile:** Coquimbo, Elqui, Paiguano, 2; Cautín, Temuco, Petal, 2; Valdivia, Riñihue, 1; Aconcagua, Papudo, 1; Valparaiso, Pamilla, La Cruz, 2. **Peru:** Ayacucho, La Mar, 2; Cuzco, Hacienda Cadena, 12; Quince Mil, 1; Huánuco, Ambo, Ambo, 1; Puno, Oconeque, 2; Santo Domingo, 3; Lima, Lima, 2. **Uruguay:** Maldonado, Maldonado, 28; Minas, Polanco, 2; Rocha, Rocha, 2. **Venezuela:** Amazonas, Puerto Ayacucho, 6; Zulia, Lagunillas, 1. **Colombia:** Cundinamarca, Bogotá, 1.

Tadarida b. intermedia: **Guatemala:** Chimaltenango, Chimaltenango, 5; Alta Verapaz, Cobán, 1. **México:** Chiapas, Comitán Valley, 10.

Tadarida b. mexicana: **United States:** Texas, Jeff Davis County, Ft. Davis, 9. **México:** Michoacán, Pátzcuaro, 13.

Tadarida b. cynocephala: **United States:** Florida, Collier Co., Marco Island, 144; Alachua Co., Gainesville, 15; Louisiana, East Baton Rouge Parish, Baton Rouge, 14.

Tadarida b. bahamensis: **Bahamas:** Long Island, cave at Tatnalls, 1; Cartwright's Cave, 1; Carlton's Hill Cave, 1; Hamilton's Cave, 3; McKinnon's Cave, 6; Pinder's Hill, 10; Burnt Ground, 1; Salt Pond, 2; Long Island (no other locality), 3.

Tadarida b. muscula: **Cuba:** Camaguey, Camaguey, 1; Pinar del Río, El Guama, 4; Oriente, Cueva de los Americanos, ½ mi. S Gibara, 8.

Tadarida b. murina: **Jamaica:** Bog Walk, 17; Tweedside, 1; Kingston, 2.

Tadarida b. antillularum: **Dominica,** 1. **Puerto Rico:** Mayagüez, 2; Caguas, 1; Manatí, 1.

Tadarida b. costanzae: **Haiti:** Bombardopolis, 1; Ft. Liberty, 1.

The Charleston Museum, Charleston 16, S. C. Received October 15, 1953.

A NEW SUBSPECIES OF *CHILONYCTERIS* FROM THE WEST INDIES AND A DISCUSSION OF THE MAMMALS OF LA GONAVE

By Karl F. Koopman

One of the most important of the island archipelagos in the study of insular speciation is the West Indian or Antillean. Though perhaps almost as interesting for such studies as the Malay archipelago, it has not been nearly so well analyzed. The last overall study of the mammalian fauna is that of Allen (1911), and many new forms have since been discovered, particularly in the Greater Antilles. A large part of the mammalian fauna consists of bats, and Chiroptera in general have not been studied very thoroughly from a zoogeographical point of view (Tate, 1946). I have felt for some time that an analysis of the West Indian bat fauna would help to round out the picture of Antillean zoogeography.

Before the general zoogeographical picture can be worked out, however, it will first be necessary to review the more important West Indian genera individually from the standpoint of speciation and zoogeography, since in most cases this has either not been done or else has been done so long ago that much new data have since accumulated. A review of the genus *Chilonycteris* is already in progress. Since, however, it will be some time before this work is finished, it is believed that a short account of a new subspecies from La Gonave, a small island off Hispaniola, would be desirable, since it would serve to present the problems encountered in work of this kind.

Material.—In March, 1929, A. J. Poole and W. M. Perrygo made a collection of owl-pellet and kitchen-midden material from caves near En Café on La Gonave (Poole, 1930). G. S. Miller (1930) reported on the native non-chiropteran mammals of this deposit. Examination of this material at the United States National Museum discloses that together with the forms mentioned by Miller (*Nesophontes hypomicrus, Brotomys voratus, Isolobodon portoricensis, Aphaetreus*

montanus, *Hexalobodon phenax*, *Acratocnus comes*), there were also human remains and post-Colombian introduced mammals (*Rattus*, *Felis*, *Canis*, *Sus*, *Capra*), also birds, lizards (*Anolis* cf. *ricordii*, *Celestus*), snakes (including *Epicrates*), tree toads (*Hyla*), and fish (including sting-ray). (More precise identification and discussion of the reptilian and amphibian fossils will be the subject of a separate paper by Dr. Max Hecht.)

Five species of bats have also been identified from skulls in this deposit. These are, in order of abundance: *Artibeus jamaicensis*, *Macrotus waterhousei*, *Chilonycteris parnellii*, *Monophyllus cubanus*, and *Mormoops blainvillei*, the last two being represented by a single fragmentary skull each. Most of the chiropteran post-cranial bones in this collection have also been tentatively allocated to these five species. All but *Chilonycteris* appear to be indistinguishable from specimens collected on the Hispaniolan mainland. The *Chilonycteris* of La Gonave, however, is definitely different from any of the mainland material examined and hence is described as a new subspecies.

Chilonycteris parnellii gonavensis, new subspecies

Type.—A skull (U.S.N.M. 295009), lacking incisors, mandibles, and ear region.

Type locality.—Cave near En Café, La Gonave island, Republic of Haiti.

TABLE 1.—*Skull measurements of Chilonycteris parnellii on La Gonave and Hispaniola*

Specimen nos. (With the exception of the type of *C. p. pusillus*, all are USNM or temporary nos.)	Condylobasal length	Palatal length	Greatest zygomatic width	Rostral width just anterior to zygomatic root	Least interorbital width	Maxillary tooth row
			C. p. gonavensis			
En Cafe						
295009 (type)	16.2	7.9	10.2	6.9	3.5	7.4
295010	16.1	7.7	10.1	6.9	3.7	7.4
295011	—	8.0	—	6.7	3.5	7.5
295012	—	8.0	—	6.9	3.6	7.5
295013	—	7.8	—	6.6	3.5	7.4
295014	—	8.1	—	6.8	—	7.6
295015	—	8.1	—	—	—	7.4
			C. p. pusillus			
Arroyo Salado						
16468 (type)	17.4	8.6	10.2	7.1	3.4	8.1
St. Michel						
293126	17.0	8.1	10.1	6.9	3.5	7.8
3A	17.4	8.2	10.3	7.2	3.5	7.9
3B	17.8	8.5	10.2	7.0	3.6	7.9
3C	17.8	8.4	10.1	6.9	3.3	8.0
3D	17.7	8.4	10.5	7.3	3.7	7.9
3E	17.5	8.3	10.3	7.1	3.8	7.9
6	—	8.4	10.2	7.2	3.6	7.8
San Raphael						
5	17.2	8.4	10.1	7.1	3.5	7.8
Diquini						
6	—	8.4	10.5	7.4	3.8	7.9

Referred material.—Six skulls and rostra, more or less fragmentary; four mandibles, not all complete; one fragmentary palate.

Diagnosis.—Smaller than *Chilonycteris parnellii pusillus*, a living form from the Hispaniolan mainland, the smallest previously known subspecies of the *C. parnellii* group. Rostrum relatively broader in relation to condylobasal length than in *C. p. pusillus* (condylobasal length/rostral width just anterior to zygomatic width 2.3 as opposed to 2.4–2.6 in *C. p. pusillus*).

Measurements.—These are given in Table 1, contrasted with measurements for *C. p. pusillus*, all, except the type, described by G. M. Allen (1911), on the mainland of the Republic of Haiti. The last locality, Diquini, is almost directly opposite La Gonave.

Remarks.—Examination of a large number of specimens from both the tropical American mainland and the West Indies has convinced the writer that *C. rubiginosa* and *C. parnellii* are conspecific. Since *parnellii* antedates *rubiginosa* by a few months, *C. parnellii* is used

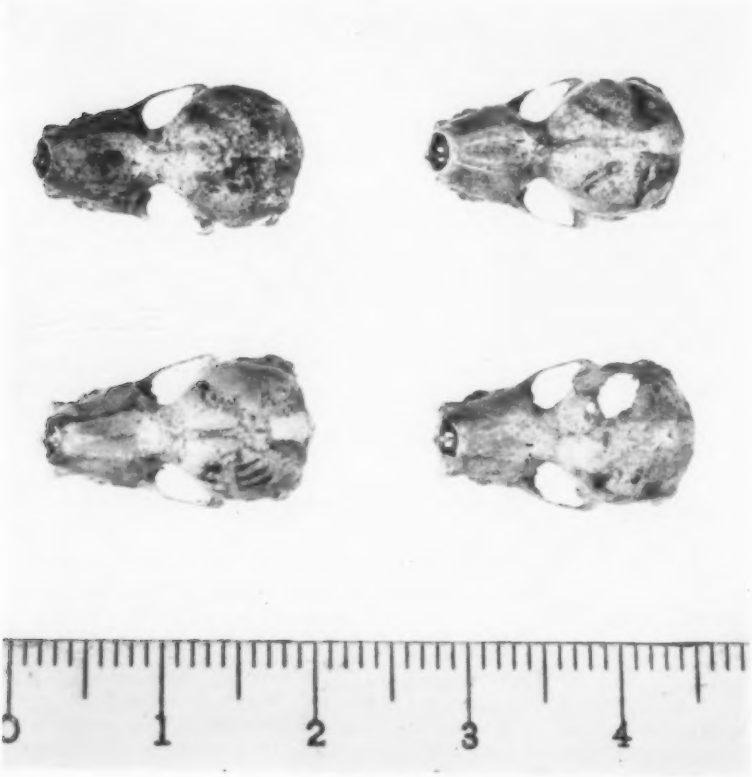

PLATE I

Skulls of *Chilonycteris parnellii* from the Republic of Haiti. LEFT: *C. p. pusillus*, upper from San Raphael, lower from St. Michel. RIGHT: *C. p. gonavensis* from En Cafe on La Gonave, upper—paratype, lower—type. The skulls of *C. p. pusillus* have been selected to show the extremes of size variation.

for the species as a whole. (Though both names appeared in 1843, *Phyllodia parnellii* Gray is dated April 11 (Proc. Zool. Soc. London, p. 50), while *Chilonycteris rubiginosa* Wagner is undated, but appears after a paper read in August [Wiegmann's Archiv für Naturgeschichte 9, vol. 1, p. 367].) The various subspecies of *parnellii* can be arranged in a graded series according to size, *C. p. rubiginosa* (*fusca* probably a synonym) of South and Central America being the largest, then *C. p. mexicana* of Mexico, next *C. p. parnellii* of Jamaica, *C. p. boothi* of Cuba, *C. p. portoricensis* of Puerto Rico, then *C. p. pusillus* of Hispaniola, and finally *C. p. gonavensis* of La Gonave. Though the difference between the largest and the smallest are very great, the differences in size between adjacent forms in the series are rather slight.

A statement concerning the status of *Chilonycteris rubiginosa fusca* is perhaps desirable. This was described by J. A. Allen (1908) from northern Venezuela and distinguished from *C. r. rubiginosa* by slight differences in size and color. Unfortunately no topotypes or near topotypes of *C. r. rubiginosa* from the Mato Grosso were available and comparison was made with specimens from southeastern Venezuela, believed to resemble topotypes on general zoogeographical grounds. I have seen no material of *Chilonycteris* from central or southern Brazil, but examination of a large series from the Rio Negro from the Brazil-Venezuela border convinces me that the characters believed to distinguish *C. r. rubiginosa* and *C. r. fusca* are not very reliable. Further study is necessary, however, to establish the pattern of geographical variation of the species in South America.

A number of humeri and radii from the same deposit are tentatively assigned to *C. p. gonavensis*. Two of the radii are complete and measure 45 and 46 mm. in length as compared with 47 mm. for a specimen of *C. p. pusillus* from St. Michel. The humeri resemble those of *p. pusillus* in length, but are more slender.

DISCUSSION

The discovery of this cave deposit considerably increases our knowledge of the fauna of La Gonave, since previously the only native mammals known from the island were the two bats, *Artibeus j. jamaicensis* and *Molossus major verrillii*. We now know one insectivore (*Nesophontes*), six bats (*Chilonycteris, Mormoops, Macrotus, Monophyllus, Artibeus, Molossus*), one edentate (*Acratocnus*), and four rodents (*Brotomys, Isolobodon, Aphaetreus, Hexalobodon*). This is a reasonably good sample of the Hispaniolan mammal fauna as a whole. It may be noted that with the exception of *Chilonycteris*, already described, none of the Gonave mammals appear to be even subspecifically distinct from those of the Hispaniolan mainland. These findings are consistent with the fact that La Gonave is a rather good-sized island (ca. 35 mi. long) and, judging from the shallowness of the water (<100 meters in depth) separating it from the mainland near Port Au Prince, must have been recently connected with Hispaniola proper. Unfortunately none of the other outlying islands around Hispaniola (Tortue, Grande Cayamite, Isle a Vache, Beata, and Saona being the more important) are well enough known mammalogically to be profitably compared. Samana peninsula, which until very recently was another separate island, appears to have a somewhat comparable mammal fauna (one insectivore, five bats, and three rodents), but without any known endemics.

It is interesting to note that several kinds of birds and reptiles restricted to La Gonave are known. Wetmore and Swales (1931) recognized one species and six subspecies of birds confined to La Gonave, though Bond (1950) considered only five as valid and these only subspecifically distinct from Hispaniolan mainland forms. They include a cuckoo (*Saurothera longirostris petersi*), a woodpecker (*Nesoctites micromegas abbotti*), a flycatcher (*Contopus caribaeus tacitus*), and two tanagers (*Phaenicophilus poliocephalus coryi, Calyptophilus frugivorus abbotti*). Six subspecies of reptiles restricted to La Gonave are recognized by Mertens (1939). These include three iguanid lizards (*Anolis distichus caudalis, A. cybotes doris, Leiocephalus personatus vinculum*), a teid lizard (*Ameiva taeniura barbouri*), and two colubrid snakes (*Uromacer oxyrhynchus dorsalis, Dromicus parvifrons alleni*). It thus appears that in spite of its presumed recent connection with Hispaniola, a number of land vertebrates on La Gonave have reached the subspecific level of differentiation.

Acknowledgements.—I am greatly indebted to the mammal department of the American

Museum of Natural History for the working facilities of the department, and to Dr. David Johnson of the Division of Mammals, United States National Museum, for the loan of material. It is also a pleasure to acknowledge the help of Dr. Max Hecht of Queens College, Dr. Bobb Schaeffer of the American Museum of Natural History, and Dr. Ernest Williams of Harvard University for aid in the identification of the non-mammalian material and for helpful suggestions in the preparation of the manuscript.

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Department of Biology, Queens College, Flushing, N. Y. Received February 20, 1953.

DESCRIPTION OF A NEW RACE OF WOODRAT FROM KEY LARGO, FLORIDA

By H. B. Sherman

In recording the occurrence of woodrats, *Neotoma floridana floridana* (Ord), from Murdock, Charlotte County, Florida (Proc. Florida Acad. Sci., 7(2&3): 201, 1945), I stated that this was the southernmost record for *Neotoma* in the state. Soon after the publication of this statment, the late Dr. Thomas Barbour told me he had seen what he believed to be woodrat nests on Key Largo and also Dr. Frank N. Young called attention to Small's article, "Green deserts and dead gardens," (Jour. New York Bot. Garden, 24(286): 215, 1923), in which the nests of woodrats on Key Largo are described as follows:

"The large woodrats of the island select a tree from beneath which they can excavate the humus. This feat is easily accomplished, for the tree usually is propped up from the rocky floor of the hammock and the humus is loose. As an addition, the rat usually builds a shack two or three feet wide and four to six feet long, composed of sticks one to three inches in diameter. These are piled up to a height of one to three feet in an irregular fashion."

Apparently no specimens of these animals were preserved until November, 1948, when, with the assistance of Joseph C. Moore, six specimens were taken. At present I have examined 24 male and 22 female specimens from this island.

FIG. 1.—Localities from which specimens of *Neotoma floridana* have been examined.

I am indebted to William B. Robertson and Joseph F. Opsahl (R&O) for the loan of three of these; William H. Burt, Museum of Zoology, University of Michigan (UM) for the loan of seven; and Albert Schwartz (AS) for the loan of 26. The other nine are in my collection (HBS). For the loan of specimens for comparison from other parts of the state, I am indebted to the American Museum of Natural History (AMNH); Cornell University Museum (CUM); Department of Biology, University of Florida (DBUF); Fish and Wildlife Service (USBS); Museum of Comparative Zoology (MCZ); Paul G. Pearson (PGP); Albert Schwartz (AS); and the U. S. National Museum (USNM).

Localities where specimens examined were collected are indicated on the accompanying map (Fig. 1). Specimens examined from each locality are as follows: *Alachua County*, Gainesville, 18, AMHN, DBUF, MCZ, HBS, UM. *Brevard County*, Micco, 2, MCZ; Oak Lodge on the peninsula opposite Micco, 3, MCZ, USBS. *Charlotte County*, Murdock, 1, HBS. *Citrus County*, Blitch Ferry, 1, MCZ; Citronelle, 1, MCZ; Chassahowitzka River, 1, USBS; Inverness, 1, AS. *Duval County*, New Berlin, 15, MCZ. *Escambia County*, Pensacola, 1, USBS. *Franklin County*, Apalachicola, 2, USBS, USNM. *Indian River County*, Sebastian, 1, USBS. *Jackson County*, Marianna, 1, USBS. *Lake County*, Eustis, 2, DBUF; Fruitland Park, 1, HBS; Leesburg, 1, HBS. *Levy County*, Gulf Hammock, 19, PGP, AS, HBS. *Manatee County*, Bradenton, 1, HBS. *Marion County*, Ocala National Forest, 1, USBS. *Pasco County*, New Port Richey, 2, USBS. *Pinellas County*, Lake Mobley, 1, USBS (also known as Lake Butler).

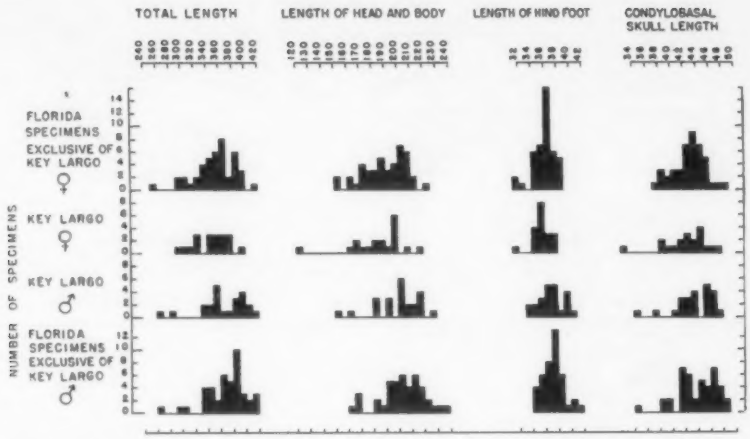
TOTAL LENGTH
LENGTH OF HEAD AND BODY
LENGTH OF HIND FOOT
CONDYLOBASAL SKULL LENGTH
FLORIDA SPECIMENS EXCLUSIVE OF KEY LARGO ♀
KEY LARGO ♀
KEY LARGO ♂
FLORIDA SPECIMENS EXCLUSIVE OF KEY LARGO ♂
NUMBER OF SPECIMENS

FIG. 2.—Measurements of specimens of *Neotoma floridana* from Key Largo in comparison with those from other parts of Florida.

Polk County, Fort Gardner, 2, USNM, USBS. *Putnam County*, San Mateo, 1, USNM. *Sarasota County*, Englewood, 1, DBUF; Sarasota, 10, CUM. *Seminole County*, Lake Harney, 9, USBS. *Volusia County*, Enterprise, 11, AMNH, USBS.

In external appearance and size I have been unable to find characters by means of which specimens from Key Largo can be separated from other Florida specimens. External measurements, recorded by histograms (Fig. 2) show that males average slightly larger than females. Fewer large specimens are present from Key Largo, which may be explained by the smaller sample from this locality.

In order to compare various skull measurements of populations from different regions, individuals were selected in which the condylobasal skull length measured from 42.0 to 46.9 mm. It seems probable that these represent sexually mature males and females and exclude a few unusually large and presumably old individuals. The testis of a specimen, in which this skull length measurement is 42.7 mm., measured 15 x 10 mm., which is about the size of those of large males. Also placental scars were noted in a female in which the skull length is 42.8 mm. Skull measurements were made by means of vernier calipers with parallel jaws. When an incisor was used in a measurement the measurement was taken from the part of its curved front surface perpendicular to the other end of the measurement. The condylobasal skull length for nearly all of the skulls measured is from 0.1 to 0.3 mm. greater on the right than on the left side. The left side of the skull was measured when possible. This difference is so slight that no correction was made in cases where the right side was measured.

Ratios in per cent of certain skull measurements to that of condylobasal skull length are shown by graphs (Fig. 3). The form of these graphs is slightly different than that described by Hubbs and Hubbs (Syst. Zool., 2 (2), 1953). The

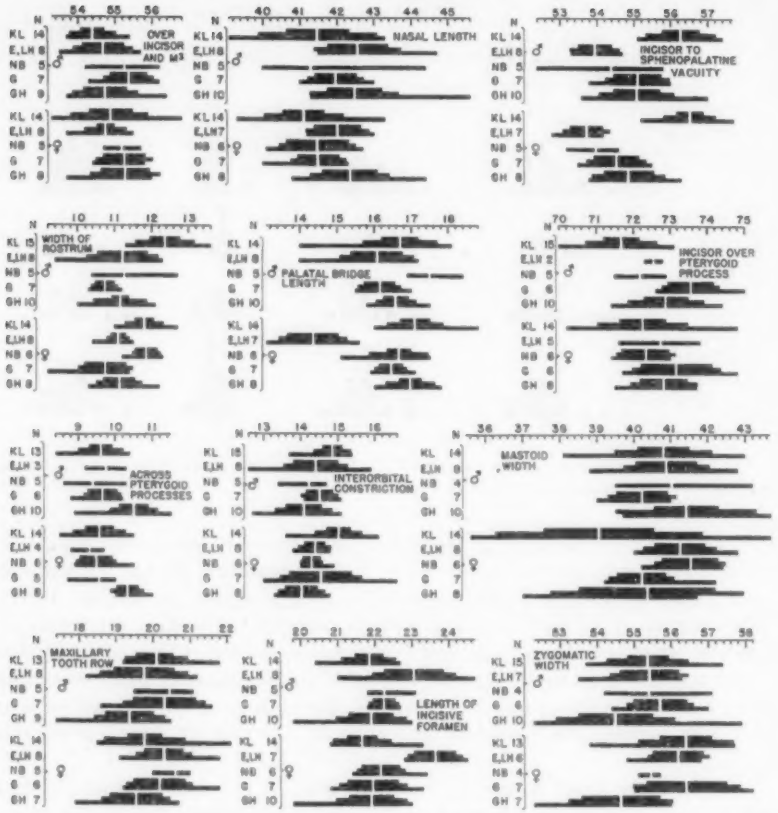

FIG. 3.—Ratios in per cent of the lengths of the 12 measurements indicated to condylobasal skull lengths. The upper bar represents twice the standard error on either side of the mean; the middle bar, one standard deviation on either side of the mean; and the lower bar the observed range. KL = Key Largo. E, LH = Enterprise and Lake Harney. NB = New Berlin. G = Gainesville. GH = Gulf Hammock.

mean is represented by a space instead of a projecting point. This was suggested by Miss Esther Coogle, the artist who made the graphs and did the drawings used in this article. It has the advantage of saving space. Also a shading film can conveniently be used for making the graph instead of covering a large area with ink.

In four of the twelve sets of graphs in Figure 3, differences of more than one standard deviation are shown for one or more of the five groups of males and females.

The ratio of distance from the front of the incisor over the pterygoid process to that of skull length is less than one standard deviation for 15 males from

Key Largo than it is for six males from Gainesville. With a larger sample from Gainesville this difference might not be so great, so there would be considerable overlapping as there is for the other three groups of males and all five groups of the females.

The ratio of length of incisive foramen to that of skull length of seven females from Enterprise and Lake Harney exceeds that for the other four groups of females by more than one standard deviation. Correlated with the long incisive foramen is the ratio of length of palatal bridge to skull length, which is less for the seven females from Enterprise and Lake Harney than for the other four groups of females. Males from these five localities cannot be separated by these two characters. It seems desirable that a larger sample be available before describing a new race on these characters, in which only females could be identified.

The ratio of the distance from the front of the incisor to the sphenopalatine vacuity to that of skull length is significantly different for all specimens from Key Largo in comparison with the other groups as shown by the non-overlapping of the bars representing twice the standard error for these samples. For this ratio, the mean and standard deviation for the 28 specimens of both sexes from Key Largo and the 94 specimens of both sexes from other parts of Florida for which this ratio is available, are respectively as follows: 56.40%, 0.66 and 54.57%, 1.07. It is thus evident that the two means are separated by slightly more than one standard deviation; 56.40 − 0.66 = 55.74; 54.57 + 1.07 = 55.64; 55.74 − 55.64 = 0.10. This indicates that about 84 per cent of the Key Largo specimens can be separated from those from other parts of the state by this character.

The shape and position of the sphenopalatine vacuities vary in relation to M^3 in these populations. The distance from the front of the incisor to the anterior end of the sphenopalatine vacuity is greater than from the front of the incisor to the posterior edge of the crown of the third molar in 35 of 36 specimens from Key Largo in which the condylobasal skull length is 42 mm. or more. The difference between these two measurements varies from 0.1 to 1.8 mm. with a mean of 0.775 and a standard deviation of 0.38 for these 36 individuals. In the exceptional case, in which the skull length is 42.5 mm., these two measurements are the same. Also these two measurements are equal in six specimens in which the skull length ranges from 41.4 to 39.0 mm. In three specimens, in which the skull length is 38.3, 35.9, and 33.8 mm., the incisor-vacuity measurement is 0.1 mm. less than the other.

In 45 of 73 specimens examined from other parts of Florida, in which the skull length is 42.0 mm., or more, the incisor—third molar measurement is greater. The difference varies from 0.1 to 1.5, with a mean of 0.48 mm. In eleven other specimens the value of these two measurements is the same. In the remaining 17 the incisor—vacuity measurement is greater by 0.1 to 0.6 with a mean of 0.36 mm. It is thus apparent that about 75 per cent of these specimens can be separated from those of Key Largo by a comparison of these two measurements.

Another noteworthy peculiarity of the position of the sphenopalatine vacuity is its anterior extent in relation to the bar which usually forms the posterior

boundary of the optic foramen. In 32 of the 46 specimens from Key Largo the anterior end of the vacuity is posterior to the bar as shown by specimen 2449 HBS (Fig. 4). In the remaining 14 it overlaps the bar by not more than half the extent of the bar. This condition, in which the vacuity is entirely posterior to the bar, has been found in only one specimen from the mainland, 1868 AS,

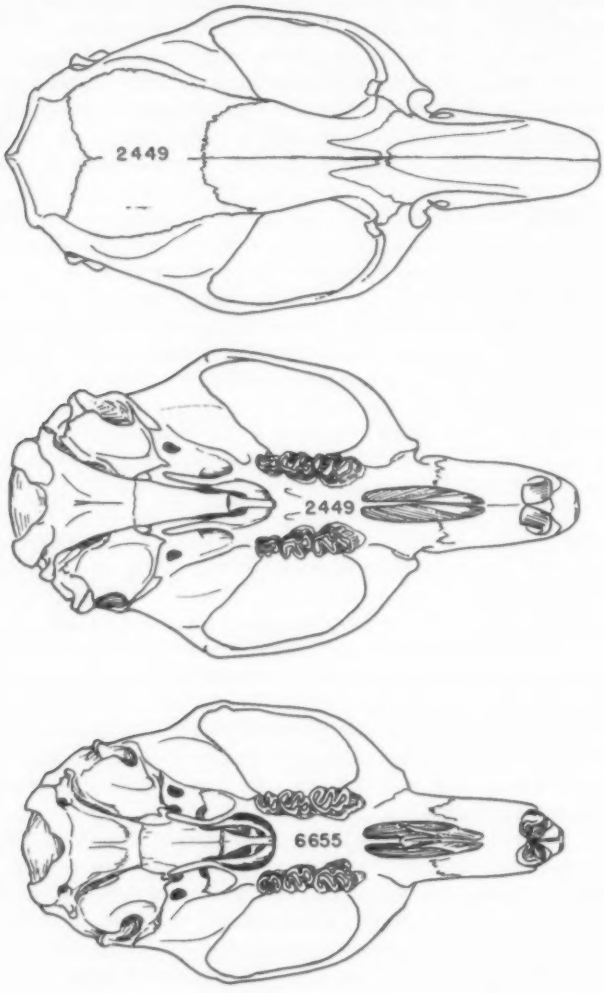

FIG. 4.—No. 2449 is the holotype of *Neotoma floridana smalli*. Specimen no. 6655 MCZ was taken at New Berlin, Florida.

from Inverness. On the other hand the anterior end of the vacuity is anterior to the anterior side of the bar in 57 of 86 specimens from the mainland. This condition is shown by specimen 6655 MCZ (Fig. 4), which was taken at New Berlin. In the remaining 29 skulls the vacuity extends at least as far forward as the middle of the bar. In four individuals this bar is absent. One of these, 2455 MCZ, is from Citronelle and the other three, 138, 159, 195 PGP, are from Gulf Hammock.

The vacuity is narrower in Key Largo specimens than in most specimens from the mainland.

The lachrymal bone projects prominently into the orbit, as shown in the figure of the dorsal view of 2449, in both Key Largo and mainland forms but is often absent in skulls that have been cleaned by boiling, apparently the method used for most of the specimens examined, except those taken in recent years.

The posterior side of the palatal bridge is notched, much as shown in the figure of 2449 in about 89 per cent of the skulls examined. It is smooth as shown in the figure of 6655 in about 9 per cent. In two specimens from Apalachicola a median spine projects posteriorly in place of a notch, as normally occurs in *Neotoma micropus*. In the single specimen I have seen from Pensacola the posterior edge of the palate is convex instead of concave. In the only specimen I have seen from Marianna the posterior edge of the palate is concave, but only slightly.

Goldman (N. Amer. Fauna 31: 22, 1910), who states that he had seen no specimens from west Florida, points out that intergradation between *floridana* and *rubida* is to be expected in that area. The need for a larger series to show what relationship exists between *N. f. floridana* and races occurring to the west is obvious.

By means of the shape and position of the sphenopalatine vacuity all but two of the specimens from peninsular Florida can be distinguished from those from Key Largo. The exceptions are 366 and 2583 HBS from Gainesville and Gulf Hammock respectively. For this reason the *Neotoma* from Key Largo are being described as a new race and named in honor of the late Dr. John Kunkel Small, who, so far as I know, was the first to mention these animals in the literature.

Neotoma floridana smalli new subspecies

Holotype.—Adult male, catalog No. 2449, collection of H. B. Sherman, skin and skeleton except for bones distal to the elbows and knees; taken on Key Largo, Monroe County, Florida, November 21, 1948, by H. B. Sherman and Joseph C. Moore.

Diagnostic characters.—Similar to *Neotoma floridana floridana* except the sphenopalatine vacuities are narrower and do not extend as far forward. They usually do not extend as far forward as the posterior edge of the bar which forms the posterior boundary of the optic foramen in *smalli*, and when they do, they overlap the bar not over half its extent. In *floridana* the anterior end of the vacuities usually extend anterior to this bar or overlap it at least half its extent. The distance from the front of the incisor to the anterior end of the sphenopalatine vacuity is greater in adult specimens of *smalli* and usually less in *floridana* than the distance from the front of the incisor to the posterior edge of the third molar.

Geographical range.—Known only from Key Largo, Monroe County, Florida.

Measurements in mm. of the holotype.—Total length, 368; tail, 167; hind foot, 37; ear from

crown, 23; ear from notch, 26; testis, 14 x 8.5; weight, 207 grams; condylobasal length, 42.7; distance from front of incisor to posterior edge of third molar, 23.3; from front of incisor to anterior end of sphenopalatine vacuity, 24.2.

In terms of Ridgeway's COLOR STANDARDS AND COLOR NOMENCLATURE (1912), the type specimen is sepia above shading into cinnamon on the sides and cream or white below. The forefeet are white to the wrist and the hindfeet are also white except for a few millimeters next to the ankles.

Forty-six specimens of this subspecies have been examined.

Department of Biology, University of Florida, Gainesville. Received March 10, 1954.

GENERAL NOTES

BANDING MEXICAN FREE-TAILED BATS

A survey of the various species of bats in Texas, both solitary and colonial, begun late in 1953 by personnel of the Texas State Department of Health, has demonstrated that an appreciable percentage of the Mexican free-tailed bats examined are naturally infected with rabies virus. Strains have been repeatedly isolated from brains and salivary glands from both healthy bats and those which appeared ill. For example, five monthly collections of *Tadarida mexicana* have been made from Bracken Cave in Comal County, Texas, starting in May, 1954. Monthly samples have included 25-30 bats and five bat brains are routinely pooled together for mouse inoculations. Each month, at least one strain of rabies virus has been isolated. A majority of the free-tailed bats studied in the laboratory have been taken from the Central Texas bat caves, due to the ease with which they can be collected during the warmer months.

Thus there is a distinct possibility that the free-tailed bats in the Southwest may be involved in the maintenance and spread of the rabies virus from bat to bat and to other wildlife and domestic animals. It is felt that this situation is of sufficient concern to warrant studies into the ecology of this species. In this connection it was decided that the best initial approach would be to band a large number of free-tailed bats, in order to obtain definite data as to their migratory habits. If it can be shown that *T. mexicana* habitually winter in Mexico in association with vampire bats, an explanation for their infection with rabies might be provided.

Five thousand size 1 aluminum bird bands were provided through the courtesy of the Fish and Wildlife Service, U. S. Department of Interior. From September 21, 1954, to October 8, 1954, 4,514 *T. mexicana* and 486 *Myotis velifer* were banded, utilizing the method reported by Trapido and Crowe (Jour. Mamm. 27: 224-226, 1946). The bands were placed along the distal portion of the forearm and adjusted loosely enough to permit their sliding freely along the bone without pinching the wing membrane. The bands were numbered 55-35001 to 55-40000. All of the bats were taken from Bracken Cave, with the exception of 700 *T. mexicana* from Ney Cave in Medina County, Texas. During the course of this work four one-day trips were made to Bracken Cave and one to Ney Cave—for an average of 1,000 bats banded per trip.

It proved unfortunate that this project was not started until September, because during this month the bat populations were found to be only around ten to twenty per cent as large as the June, July and August colonies. Consequently, the three of us doing this work expended the greater part of our efforts in collecting the bats. Insect nets with extension handles were utilized for raking the bats off the walls and ceilings. The captured bats were placed in apple boxes modified by covering the top and bottom with screen wire and adding a sliding panel door eight inches in width to the top. When a box contained three or four hundred bats it was carried to the entrance of the cave and the bats banded. Working in these bat caves is particularly unpleasant during the summer months, as the guano is over

a foot deep in spots, the ammonia fumes are strong, ectoparasites are present in abundance and the heat is intense.

Surprisingly enough, when the last banding trip was made to Bracken Cave on October 8, 1954, no difficulty was experienced in netting all of the bats needed. Although not approaching the June, July and August population level, free-tailed bats were numerous.

The actual banding of the bats did not prove to be time consuming. The bands were opened with an awl, made from an old ice pick, before going into the field, and placed in small pill boxes. When a modified apple box full of bats was brought to the cave entrance it was set on a small folding table, in order to facilitate removal of the bats. It was found that one person could fasten the bands as rapidly as two workers wearing leather gloves could remove the bats from the box and hold out the forearm for banding.

The cooperation of the Pan American Sanitary Bureau and Mexican Officials has been requested in reporting the recovery of any of these banded bats in Mexico this winter. We would particularly like to alert any of the members of the American Society of Mammalogists that plan to collect mammals in Mexico. It is anticipated that an even larger number of free-tailed bats will be banded during the summer of 1955.—R. B. Eads, J. S. Wiseman, and G. C. Menzies, *State Department of Health, Austin, Texas. Received October 28, 1954.*

SOME MAMMAL LOCALITY RECORDS FROM IOWA

Trapping for small mammals in the State of Iowa during the past year has resulted in some interesting data. On September 10, 1952, a specimen of *Sorex cinereus cinereus* was brought into the author's laboratory by a man who stated that the shrew had entered the office of a manufacturing firm located on the northwest edge of Davenport, Scott County, Iowa. This represented a seventy-five mile southward extension of the known range of this animal. Previous records had established the occurrence of this shrew as far south as Dubuque, Dubuque County, Iowa (Scott, Iowa State College Jour. Sci., 12: 53). Subsequent trapping proved that this animal is quite common in most natural habitats in Scott County, and six additional specimens have been taken.

The author extracted two skulls of the harvest mouse (*Reithrodontomys megalotis dychei*) from the pellets found under an owl roost in a white pine grove near Davenport. Several members of the local bird club also had shown the author parts of skulls of this mouse from the same locality. Trapping in the area failed to yield specimens of this mouse until a small abandoned cornfield was trapped. This field was approximately one and three quarter miles from the roost. Two specimens of this harvest mouse were taken. Although this mouse has been reported before from eastern Iowa (Scott, *ibid.*: 74), it has never been taken in Illinois.

The author spent the period from July 19 to August 20, 1953, at the Iowa Lakeside Laboratory in Dickinson County, Iowa, and with the exception of a one night trapping trip eighty miles eastward to Hancock County, trapped there every night. Many interesting mammals were collected.

The jumping mouse (*Zapus hudsonius*) was extremely common in nearly every habitat, perhaps showing a preference for fence rows and grazed, blue grass meadows. Krutzsch (Univ. Kansas Publs., Mus. Nat. Hist., 7: 349–472, 1954) has recently assigned jumping mice from this area to a new subspecies, *Z. h. intermedius*.

The eastern grey chipmunk (*Tamius striatus griseus*) was very common in the wooded areas near the lakes in Dickinson County. Apparently this population has been overlooked by workers in the past because Scott (*ibid.*, 1937) mentions that it is most common in the northern and eastern parts of the state; and on the distribution map in Burt and Grossenheider (A field guide to the mammals: 76, 1952) the area of northwestern Iowa is left blank. Several specimens have been added to the Davenport Museum collection from this area.

Scott (*ibid.*, 1937) lists the grasshopper mouse (*Onychomys leucogaster breviauritus*) as occurring in the state but states that it probably was accidental because only one specimen had been collected in 1923 and further collecting by him and workers of the Iowa Lakeside Laboratory had failed to yield additional specimens from the locality listed for the one

specimen. During early August, 1953, the author on successive nights collected four specimens of this mouse from an uncut stretch of prairie, locally called Caylor Prairie, about three miles west of the laboratory. These specimens provide additional proof that the grasshopper mouse should be included as a permanent resident of Iowa.

One specimen of the whitetail jackrabbit (*Lepus townsendi campanius*) was collected and another one seen in Dickinson County in five weeks. This rabbit seems to be decreasing in Iowa and is already scarce or missing in Eastern counties.

The trapping trip to Hancock County, mentioned earlier, was inspired by a report that the redback mouse (*Clethrionomys gapperi loringi*) had been trapped there. Two specimens, representing the first authentic records from the state, are located in the Museum of Zoology, University of Michigan. These were collected, according to the label, from 5 mi. E. Forest City, Hancock County, Iowa. Hall and Cockrum (Univ. of Kansas Pubs., Mus. Nat. Hist., 5: 388, 1953) have changed the designated locality to ESE. and the author agrees that this is valid on the basis of habitat and county lines. Five miles east would be Winnebago County. Pilot Knob State Park is located approximately 5 mi. ESE. of Forest City and is in Hancock County. This park is covered with a thick forest of oak and aspen. The author placed 100 museum-special traps in all types of habitats within the woods, and from this one setting collected 21 *Clethrionomys*, 26 *Peromyscus leucopus noveboracensis*, 3 *Blarina brevicauda brevicauda*, 2 *Sorex cinereus haydeni* and one *Zapus hudsonius*. No other locality for redback mice has been discovered in Iowa to this date and the author assumes that his specimens are from the same population as the University of Michigan specimens.

Gray squirrels (*Sciurus carolinensis leucotis*) were seen in Pilot Knob State Park. This is considerably west of the published records from the state (Scott, ibid., 1937), but certainly falls within the overall known range of the species (Burt and Grossenheider, Ibid.: 79, 1952).

No harvest mice (*Reithrodontomys megalotis dychei*) or prairie voles (*Microtus ochrogaster*) were collected during the five weeks of trapping. The author has found that the populations of both of these mice are distributed in pockets and are very erratic in location.

On October 3, 1953, the author was collecting plants in the area of Wild Cat Den State Park, Muscatine County, Iowa. In one area it was noted that matted blue grass, blackberry brambles, sumac and an occasional tree dominated the habitat. He was reminded so strongly of a similar situation near Monticello, Illinois, where specimens of the lemming mouse (*Synaptomys cooperi saturatus*) had been collected at an earlier date, that a search was made for runways. Runways were found indicating the presence of some microtine rodent, and the characteristic bright green droppings of *Synaptomys* were found. On October 10, traps were set in the area and two specimens of the lemming mouse (*Synaptomys cooperi*) were obtained. Future trapping may indicate that this animal is well established in eastern Iowa and may reveal additional information about the subspecific status of the lemming mouse in Iowa.

Specimens of the spotted skunk (*Spilogale interrupta*) seen by the author from Scott County, and individuals seen dead on the road in Clinton County and Dubuque County, indicate a fairly large population along the eastern edge of Iowa. Spotted skunks have been seen occasionally by sportsmen and trappers on islands in the Mississippi River and although never recorded in the literature from Illinois surely must cross over to that state on the ice in the winter via these islands.

Almost every opportunity the author has had to trap in Iowa has resulted in new county records, overall range extensions or the rediscovery of populations of mammals considered rare heretofore. These data can be construed to mean that the study of Iowa mammals has been neglected in the past and that a really comprehensive field study is necessary to assure us in any degree that the mammals of Iowa are adequately known. The author and the Davenport Public Museum propose to conduct such a study and workers in our area are invited to participate.—Lowell S. Miller, *Davenport Public Museum, Davenport, Iowa.* *Received November 10, 1953.*

DISTRIBUTIONAL NOTES ON SMALL MAMMALS IN NORTHERN MANITOBA, CANADA

During the week of August 16 to 23, 1953, a series of small mammals was collected by the writer at Churchill, Manitoba. This locality appears to be outside of the known limits of the geographical ranges of three of the species represented in the series. It was therefore thought desirable to record the specimens involved in these range extensions.

Sorex cinereus.—The range of this species was not shown to reach as far north as Churchill on the west side of Hudson Bay by Jackson (N. Amer. Fauna, 51: 39, 1928), and I have been unable to find reports of its occurrence here in more recent accounts. Five specimens were collected. The average and extreme measurements are: total length, 96 (92–102) mm.; tail, 38 (36–39); hind foot, 12 (12–13).

Lemmus trimucronatus.—The previously most southern record for this species on the west shore of Hudson Bay is apparently the mouth of the Thlewiaza River, which is north of latitude 60° (Preble, N. Amer. Fauna, 22: 54, 1902). Recent reviewers (Davis, Murrelet, 25: 19–25, 1944; Anderson, Bul. Nat. Mus. Canada, 102; 147, 1946); Hall and Cockrum, Univ. Kansas Publs. Mus. Nat. Hist., 5: 472, 1953) do not extend the range south of the 60th parallel. A single specimen was collected at Churchill (total length, 128 mm.; tail, 22; hind foot, 20). This record extends the range south about 100 miles to between latitudes 59° and 58°.

Synaptomys borealis.—The previously most northern recorded locality on the west side of Hudson Bay is Ilford (Anderson and Rand, Canadain Field-Nat., 57: 101–103, 1943). Four specimens taken at Churchill extend the range northward about 200 miles. The measurements of three of these specimens are: total length, 127, 117, 115 mm.; tail, 22, 23, 24; hind foot, 19, 20, 20.—W. B. Quay, *Department of Anatomy, University of Michigan, Ann Arbor. Received November 30, 1953.*

ANOTHER RECORD OF THE LEAST SHREW FROM NORTHEASTERN COLORADO

Four specimens of the least shrew (*Cryptotis parva parva*) previously have been recorded from Colorado, all from Yuma County, Colorado, near the Kansas-Nebraska state lines. Two individuals collected on Dry Willow Creek north of Wray were reported by F. W. Miller in 1924 (Jour. Mamm., 5: 199) and two were trapped east of Wray at Laird on November 2, 1952 (Jones and Loomis, Jour. Mamm., 35: 110, 1954).

On November 14, 1952, Eugene M. Gray, then a member of the Colorado Game and Fish Department, found and killed two least shrews alongside Highway U.S. 138 about five miles west of Crook, Logan County. The animals, both females, were discovered under a maggoty deer hide in somewhat marshy, burned-over grassland. These specimens, now in the Colorado A & M College mammal collection (Cat. No. 228) and at the University of Colorado Museum (Cat. No. 5794), measured, respectively: total length, 78 mm., 84; length of tail vertebrae, 17, 20; length of hind foot, 11, 11; ear from notch, 6, 5; weight, 5 grams, 5.6.

This record extends the known range of the least shrew in Colorado more than forty miles westward.—Richard G. Beidleman and Jack D. Remington, *Zoology Department, Colorado A & M College, and Colorado Game and Fish Department, Fort Collins. Received February 28, 1954.*

NOTES ON IRAQ INSECTIVORA AND CHIROPTERA

The following mammals were identified by Dr. H. W. Setzer and are deposited in the U. S. National Museum. The ectoparasites were identified by J. Bequaert and H. Hoogstraal and are in their charge.

INSECTIVORA

Hemiechinus calligoni Pall. Hedgehog (known as "Kumfith" or "Kumphid" in Arabic).—Identified from a small specimen taken February 19, 1951, and a large specimen taken

July 5, 1952 in Baghdad. The smaller specimen was kept in captivity until February 24. When handled it would not bite but would curl up tightly in a ball so that the buff-colored ventral fur, which lacked spines, would not show. Then, if undisturbed, it would slowly uncurl, exposing first the big ears (which were 27 mm. long) and long snout. In a wire mesh cage it ran about freely, attempting to cut the mesh with its protruding long, strong incisors. At first it gave no indication of having ectoparasites as it ran about or when handled. Later, when I attempted to open the tightly curled animal several fleas and many ticks appeared. The ticks (*Rhipicephalus s. sanguineus* [Latr.]) when disturbed folded their legs tightly and dropped freely from the fur. The fleas remained. As the hedgehog seemed to fail in health, more and more fleas and ticks appeared, including many immatures of the latter.

While hedgehogs are probably common in Baghdad throughout the year, it is the flooding of gardens from the winter rains and the rising Tigris River that brings them to the attention of people. They are occasionally found run over by automobiles on roads and have somewhat the rôle of skunks in that respect, being vulnerable as they forage at night.

CHIROPTERA

Pipestrellus k. kuhlii Kuhl.—Identified from specimens taken in Baghdad December 26, 1950, May 12, 1951 and May 17, 1952. This appears to be the common species here. The bats of this species, with possibly one or two other species, fly freely about during nearly all of the year. Shortly before sunset bats become active over the streets and swoop down just above pedestrians and domestic animals as they capture insects. Both in 1950 and 1951 they became less numerous in late November and early December, disappearing during the coldest weeks of December–February.

The December 26 bat had been resting torpidly in a roll of reed matting on the north side of a house and tumbled sluggishly out when the matting was unrolled at 4:00 PM. The minimum temperatures the preceding ten nights at approximately this site varied from 3°C. (37°F.) to 9.5°C. (49°F.), the maxima from 17.8°C. (64°F.) to 20°C. (68°F.). The lowest minimum temperature reached thus far in the winter was 3°C. (37°F.) and 17.8°C. (64°F.) was the lowest maximum. It is probable that a succession of nights in the range of 3°–5°C. (37°–41°F.) and maxima in the range of 17.8°–20°C. (64°–68°F.) are sufficient to induce a degree of torpidity. There are still insects about during these conditions but they are the types that are active in the sun and hence not available for bats. On February 17, when the maximum was 20.6°C. (69°F.) and the minimum 8.9°C. (48°F.), bats were noticed for the first time in weeks. This was the highest combination of temperatures except once or twice in January.

The bat did not attempt flight but was capable of clicking its teeth and moving sluggishly. It was kept in a cage where it clung to the wire netting sides, and was completely inactive at temperatures in the range 10–20°C. (50°'s and 60°'s F.). On January 7, when it was preserved, it was found to have a wingspread of 227 mm., a total length of 83 mm., and ear length of 10 mm. (6 mm. along median margin), tail 30 mm. and hindfoot length of 7 mm. The bat was an even gray ventrally and darker gray with a tinge of brown dorsally. The interfemoral membrane was complete except at the very tip of the tail. The dentition was the average insectivorous type. There were three adult and patterned mites and one white nymph on the wing membrane.

The May 17 record consisted of half-grown young taken at the College of Arts and Science, Baghdad (collected by Rafi al Hafidh) and several mites and ticks were taken from them, the latter identified as *Argas fischeri*. Ecological data on an El Gaim, Euphrates River record are given below under *Asellia*. These appeared to be half-grown. The species was taken nearby at T1 Pipeline Station, latitude 34°13′ north, longitude 41°21′ east, June 25, 1952, where a specimen was taken in a narrow crevice between the side of a house and the wooden beam of a shelter. It was understood that they had been common here but because of their unsightly droppings nearly all crevices suitable for them had been filled in. Probably the good they did in capturing mosquitoes and other insects far outweighed the nuisance aspect.

Asellia tridens murraiana Anderson.—The palest bats seen in Iraq were these. Their fur is a light, silky yellow in color. Two were taken along the Euphrates River near the Syrian border at El Gaim (latitude 34°23′ north, longitude 41°13′ east), June 25, 1952. The bats each carried one or more ticks which soon left them after captivity and were lost. They may have been *Argas fischeri*. The bats, together with the smaller and darker *Pipistrellus kuhlii*, occurred at mid-day under the corrugated iron roof of a small, open and empty shed of a water-pumping system. At this time the windswept, noon, surface desert temperature nearby in the open was 41°C. (105.8°F.) and on the rocky surface at the entrance to a shallow cave in the sun 56.5°C. (134°F.). The desert sun temperature at a height of 50 cm. above the ground, in a light wind, was 36.5°C. (98°F.). The temperature inside the shed where the bats were clinging must have been at least 38°C. (100°F.). They did not show torpidity at this temperature but flew about inside the shed when they were disturbed. It was significant that they did not attempt to leave it for the blinding and hot sunshine.

Taphozous kachensis magnus Wett. (= *Liponycteris kachensis magnus*).—This large bat was taken at the ancient Ctesiphon Arch some 20 miles southeast of Baghdad May 26, 1952 (collected by Adnan Mustafa). It is a large bat with a tail protruding through the interfemoral membrane, has long sensory hairs extending from the dorsal bases of the toes to a position well forward, and has several pads on the wings where it presumably clings to hard surfaces. It was taken here in 1918 by British soldiers and it is interesting to speculate that the species may have been dwelling in this arch for many centuries. It carried a large tick (*Argas fischeri*). The sun air temperature at the time (10:00 AM) in a light wind at a height of 50 cm. was 39°C. (102.2°F.), though in the shade inside the arch (also in the wind), it seemed cool at 37°C. (98.6°F.), also at 50 cm. above the ground. Under these conditions the bats did not attempt flight but sought deeper parts of the crevices in the bricks.

Unidentified bats, which were probably *Pipistrellus kuhlii*, foraged with regularity for winged ants (*Camponotus thoracicus xerxes* Forel) in our garden in Baghdad in the Spring of 1952. These are the largest ants in this part of Iraq, the males being 11 mm. and the winged females 14 mm. long. A colony nested at the base of the brick wall that surrounded the house and garden and the sexual forms appeared for the first time in March. On March 28 at 6:35 PM the female ants were climbing rose bush and orange tree foliage, then taking flight vertically into the calm evening sky. Over a dozen bats appeared overhead and, as the ants would take off singly or a few at a time, the bats swooped down to as low as two meters above the ground to pick them off. At 6:40 the temperature was 20.8°C. (69°F.) and the height of the flight was attained. By 6:55 when it had become quite dark and a thin slice of new moon had appeared, fewer males and females were taking flight and fewer bats were left. By 7:05 it was dark with no bats overhead and no ants appeared to be flying. A mile or two away and across the Tigris River on the same evening Dr. A. Craig-Bennett reported a flight of these ants. There were no bats at 6:33 though dragonflies were capturing the ants. By 6:37 the bats had appeared here and were taking them.

The next night at the same time a similar flight probably occurred but could not be verified after 6:30 PM. At 6:32 PM March 30, however, many male ants were flying off but no winged females or bats had appeared. At 6:38 three bats appeared and at 6:41, in gathering dusk, a bat was watched as it captured a female ant at a height of about seven meters and about ten meters to one side, turning sharply in the air to bag the ant. Immediately seven to ten more bats appeared and captured every ant that took flight. At 6:44 no ants were taking flight and by 6:48 the distribution of bats had become scattered as was normal at this time when no ants were flying.

March 31 the same ant nest erupted more winged forms from about 6:30 to 6:46 PM. At 6:33 no bats were overhead but by 6:37 the ant flight was in full force and about six bats were picking them off. At 6:44 there were about ten bats and at 6:46 one was watched as it captured a female ant, turning sharply in mid-air from a distance of a meter or so from the ant. April 3, following several hot and drying windy days, a short flight of ants took place with one or two bats capturing them at 6:45 PM; no ants appeared at 6:50 and bats overhead appeared to be capturing mosquitoes. April 5, a flight of ants occurred with males most numerous and during the 6:30–6:46 period no bats were to be seen. April 6 from 6:35 to

6:45 during an ant flight no bats appeared until 6:45, when one came over in the fast-gathering dusk with a bright moon overhead. April 21, after a quiescent period, the ants resumed flight and at 6:50 PM of an overcast, warm evening at least ten bats were overhead capturing them.

During this period of nearly a month other species of winged ants had been emerging from nests in our house and garden but had not attracted the bats. Mostly they had been flying earlier in the evening. On numerous other occasions evening flights of small ants had been seen which did not attract bats. It seemed probable that it was the large size of the heavy-bodied *Camponotus* females that attracted them and there is little doubt but that these ants were as nutritious, being full of eggs, as any insects they could capture. It is also probable that this is about the maximum size of prey for *Pipistrellus*.—NEAL A. WEBER, *Swarthmore College, Swarthmore, Pennsylvania.* *Received February 15, 1954.*

ADDITIONAL DISTRIBUTIONAL RECORDS OF BATS IN UTAH

There are few published records of occurrence of bats in the State of Utah. Hardy (Jour. Mamm., 22: 289–295, 1941) recorded 23 species and subspecies from the State, basing his list on a summary of the published data and on 205 new specimens. Durrant (MAMMALS OF UTAH, Univ. Kans. Publs. Mus. Nat. Hist. 6: 1–549, 1952) reduced this number to 19 species and subspecies; excluding from Hardy's list *Myotis yumanensis sociabilis*, *Myotis californicus californicus*, *Myotis thysanodes thysanodes*, and *Antrozous pallidus cantwelli* all of which were not known by Utah-taken specimens.

The present paper is concerned with additional distributional records for the bats already known from the State and adds one species (*Myotis thysanodes thysanodes*) to the chiropteran fauna. This report is based upon 58 specimens (skins with skulls) in the collection of Carnegie Museum, Pittsburgh, Pennsylvania. Most of these specimens were obtained by J. Kenneth Doutt, A. C. Lloyd, and W. F. Wood, in the summer months of 1933, 1935, 1936, 1938, and 1940.

The following annotations about the species studied include data concerning: the locality of collection, the number and sex of the animals obtained, and, when available, notes regarding the natural history of the species concerned.

Myotis lucifugus carissima Thomas.—An adult ♀ of this species was obtained 2 mi. SW Jensen, Uintah County, on August 1, 1935, by A. C. Lloyd. This specimen represents the easternmost record of this species in Utah. *Specimen examined.*—Uintah County: 2 mi. SW Jensen, 1 ♀.

Myotis yumanensis yumanensis (H. Allen).—Heretofore this bat was known from Utah by only two authentic records. These specimens, both from Washington County, led Durrant (*op. cit.*: 43) to state that, "... *M. y. yumanensis* occurs in only the extreme southern part of the state." We have specimens from two localities in Uintah County: 2 mi. SW Jensen and 15 mi. SW Ouray, along Green River, 4500 ft. These extend the known range of this species more than 300 miles to the northeast and indicate that *yumanensis* probably occurs throughout the arid or semiarid areas in southern and, perhaps, central Utah. *Specimens examined.*—Uintah County: 2 mi. SW Jensen, 17 (13 ♀♀, 4 ♂♂); 15 mi. SW Ouray, 2 (1 ♀, 1 ♂).

Myotis evotis evotis (H. Allen).—A single adult female of this species was taken 2 mi. above White River, Uintah County on June 11, 1943. The bat was shot by J. Kenneth Doutt as it foraged near a groove of yellow pine in the early dusk. This is the fifth (and northeasternmost) specimen of *evotis* recorded from Utah. *Specimens examined.*—Uintah County: 2 mi. above White River, 1 ♀.

Myotis thysanodes thysanodes Miller.—Two adult males of this species were obtained 4 mi. N Thompsons, Grand County, by W. F. Wood, on July 29, 1940. These are, to our knowledge, the first Utah-taken specimens of *Myotis thysanodes thysanodes*. The bats, both adult males, are more pallid than specimens known to us from southern and central California; however, the material is insufficient to allow for taxonomic evaluation. *Specimens examined.*—Grand County: 4 mi. N Thompsons, 2 ♂♂.

Myotis californicus stephensi Dalquest.—Durrant (*op. cit.*: 47) recorded only six specimens of this species from Utah. We have 15 additional specimens which were obtained from two new localities: 4 mi. N Thompsons, Grand County and from Thorne's Ranch, Willow Creek, 45 mi. S Ouray, Uintah County. These localities extend the known range of *stephensi* 30 miles to the east and north. The specimens from Thorne's Ranch were collected by J. Kenneth Doutt. One individual was taken from a roosting place in the bunkhouse and the second was shot at early twilight as it foraged low (15 ft.±) over the horse corral. *Specimens examined.*—Grand County: 4 mi. N Thompsons, 13 (9 ♀♀, 4 ♂♂). Uintah County: Thorne's Ranch, Willow Creek, 45 mi. S Ouray, 2 ♂♂.

Myotis subulatus melanorhinus (Merriam).—Two adult females (typical of this subspecies), were obtained at Powder Springs, 25 mi. E Vernal, Uintah County, by H. J. Clement. This extends the known range for *M. subulatus melanorhinus* (in Utah) some 50 miles to the northeast. *Specimens examined.*—Uintah County: Powder Springs, 25 mi. E Vernal, 2 ♀♀.

Lasionycteris noctivagans (LeConte).—We have two new localities in Utah for this species. On August 20, 1936, J. Kenneth Doutt shot an adult male as it foraged over an open, grassy, alpine meadow, 15 mi. N Mountain Home, Duchesne County. Doutt obtained another specimen 15 mi. SW Ouray, 4500 ft., Uintah County. This bat was shot as it foraged in relatively straight, steady flight over the Green River. *Specimens examined.*—Duchesne County: 15 mi. N Mountain Home, 1 ♂. Uintah County: 15 mi. SW Ouray, 1 ♂.

Pipistrellus hesperus hesperus (H. Allen).—Durrant (*op. cit.*: 51) records 53 specimens of this bat from Utah and suggests that the species is nearly statewide in distribution. We are of the opinion that Durrant might well have refined his statement to indicate that arid and semiarid areas are probably required. We have five new records of occurrence of *Pipistrellus*; most of these are from eastern Utah. Three adult females obtained by J. Kenneth Doutt near Green River, 15 mi. SW Ouray, 4700 ft., Uintah County, extend the known range of this species 50 miles to the northeast. *Specimens examined.*—Grand County: mouth of Florence Creek Canyon, 4300 ft., 35 mi. N [of the town of] Green River 2 (1 ♀, 1 ♂); 4 mi. N Thompsons, 4 (1 ♀, 3 ♂♂). Uintah County: Desert Springs, 10 mi. SW Ouray, 1 ♀; near Green River, 15 mi. SW Ouray, 4700 ft., 3 ♀♀. Wayne County: 7 mi. SE Fruita, 1 ♂.

Eptesicus fuscus pallidus Young.—We have only a single specimen of *pallidus*, an adult male, taken at the mouth of Florence Creek Canyon, 4306 ft., 35 mi. N [of the town of] Green River, Grand County. This bat is notably pallid, but compares favorably in cranial and external dimensions with a series of *pallidus* from San Diego County, California. *Specimen examined.*—Grand County: mouth of Florence Creek Canyon, 4306 ft., 35 mi. N [of the town of] Green River, 1 ♂.

Corynorhinus rafinesquii pallescens Miller.—We have two specimens, both from Grand County: one individual was shot by J. Kenneth Douit as it foraged in the early twilight at Post Canyon, 8200 ft., Book Cliffs on September 1, 1936, and the other was obtained by W. F. Wood, 4 mi. N Thompsons on July 31, 1940. Both bats are adult females and represent the first reported occurrence of this bat in east-central Utah. *Specimens examined.*—Grand County: 4 mi. N Thompsons, 1 ♀; Post Canyon, 8200 ft., Book Cliffs, 75 mi. S Ouray, 1 ♀.

Antrozous pallidus pallidus (LeConte).—We have two specimens of *Antrozous* from Utah. Both individuals are slightly darker in color than specimens of *A. p. pallidus* from Vallecito, San Diego County, California; however, in external and cranial dimensions they are similar to the Vallecito-taken specimens and smaller than specimens of *Antrozous p. pacificus* from San Marcos, San Diego County, California. A specimen from Dinosaur Quarry, 5500 ft., 6 mi. N Jensen, Uintah County, is the northernmost record for the State. *Specimens examined.*—Grand County: 10 mi. N Moab, Arches Monument, 1 ♀. Uintah County: Dinosaur Quarry, 5500 ft., 6 mi. N Jensen, 1 ♀.—PHILIP H. KRUTZSCH AND CAROLINE A. HEPPENSTALL, *Department of Anatomy, School of Medicine, University of Pittsburgh, and Section of Mammals, Carnegie Museum, Pittsburgh, Pennsylvania.* *Received January 29, 1954.*

NEW RECORDS FOR BATS IN OKLAHOMA

A cave in the northwest corner of Adair County, Oklahoma, five miles south of the little town of Kansas, has long been known to harbor bats. Previously *Myotis grisescens*, *Pipistrellus s. subflavus*, and *Eptesicus f. fuscus* have been taken from this location. The former species uses the cave as a maternity ward every spring and summer, and may be found there at other seasons. The latter two are usually found only while hibernating.

On October 24, 1952, Mr. Carl Carnahan, a student at Oklahoma A. & M. College, entered the cave to procure some bats for the college museum collection. The bats, except for a few *P. subflavus*, were all taken from a single cluster near the rear of the cave. They were brought to Stillwater, where most of them were dead on arrival. The majority of the specimens were of the species *Myotis grisescens*, but among them were two *Myotis sodalis*, a male and a female. All of the specimens were in a dormant condition when captured.

Miller and Allen (U. S. Nat. Mus. Bul., 144: 130–133, 1928) give the western limit of *M. sodalis* as Greenway in northeast Arkansas. Sealander (pers. comm.) informs me that it is often found in the caves of northwest Arkansas. The Ozark region of Oklahoma is therefore within the expected range of the species, but these specimens are the first positive evidence of its occurrence.

The pipistrel, *Pipistrellus subflavus*, has not previously been found in the gypsum caves of western Oklahoma, although it is reported from a similar formation near Sun City, Kansas. The westernmost record for Oklahoma is 10 miles south and 2 miles east of Sulphur, Murray County (Blair, Amer. Midl. Nat., 22: 100, 1939).

On November 28, 1953, Oklahoma A. & M. College students, Heard and Talley, entered two caves in southwest Oklahoma to search for bats for the college museum collection. From a cave three and one-half miles north of Jester, in Greer County, three *P. subflavus* were taken. Later the same day a single specimen was taken from a well-known bat cave in Harmon County, three miles west and one mile south of Reed, on the north bank of the North Fork of the Red River. In both instances *Myotis velifer incautus* and *Corynorhinus rafinesquii pallescens* were also secured.

On April 20, 1954, the writer and Heard collected bats in Alabaster Cavern, Woodward County, Oklahoma. One *P. subflavus* was taken in the lowest recess of the cave, near but not associated with numerous *M. v. incautus*. A single *Eptesicus fuscus pallidus* was the only other bat seen at this time, although on other trips *Tadarida mexicana* and *Corynorhinus rafinesquii pallescens* have also been taken from this cave.

The area in which these caves are located lies approximately 180 to 230 miles west and northwest of the Murray County locality mentioned above, and is characteristic of the arid Southwest, both in flora and fauna. In the caves there was moisture present, and the bats were sleeping in the most moist places, with condensed droplets visible on the fur. This leads one to speculate that suitably humid hibernation sites may be the factor regulating the western limit of the range of this species.—Bryan P. Glass, *Department of Zoology, Oklahoma A. & M. College, Stillwater.* (*Department of Zoology Contribution No. 234.*) *Received March 12, 1954.*

NOMENCLATURE OF SOME TERTIARY CHIROPTERA

Although Pierre Revilliod's monograph on Tertiary Chiroptera [CONTRIBUTION A L'ÉTUDE DES CHIROPTÈRES DES TERRAINS TERTIAIRES, Mém. Soc. Paléo. Suisse, Part I (Vol. 43. 1917), Part II (Vol. 44, 1920), and Part III (Vol. 45, 1922)] is well known, another of his publications dealing with the same subject has been largely overlooked. This is a brief summary of the entire monograph published by Revilliod in 1919 [L'état actuel de nos connaissances sur les Chiroptères fossiles (Note préliminaire), Compte Rendu Soc. Phys. Hist. Nat. Genève, 36(3): 93–96.] In this review Revilliod mentioned all the species and genera, most of them by name accompanied by brief diagnoses, that he described in greater detail as new in the 1920 and 1922 parts of the monograph. The names thus involved are as follows:

Rhinolophus priscus. Nomen nudum 1919, p. 94; described 1920, p. 64.

Rhinolophus pumilio. Nomen nudum 1919, p. 94; described 1920, p. 66.

Rhinolophus lemanensis. Nomen nudum 1919, p. 95; described 1920. p. 67.
Nyctinomus stehlini. Nomen nudum 1919, p. 95; described 1920, p. 108.
Nyctinomus helveticus. Nomen nudum 1919, p. 95; described 1920, p. 124.
Stehlinia. Described as a new genus 1919, p. 94; redescribed as *Nycterobius* 1922, p. 133.
Stehlinia gracilis. Described 1919, p. 94; redescribed as *Nycterobius gracilis* 1922, p. 133.
Myotis salodorensis. Described 1919, p. 94; redescribed 1922, p. 136.
Samonycteris. Described as a new genus 1919, p. 95; redescribed 1922, p. 139; listed by Simpson as 1922.
Samonycteris majori. Described 1919, p. 95; redescribed 1922, p. 139.
Paleunycteris. Described as a new genus 1919, p. 95; redescribed 1922, p. 144; listed by Simpson as 1926.
Paradoxonycteris. Described as a new genus 1919, p. 95; redescribed 1922, p. 150; listed by Simpson as 1926.
Paradoxonycteris soricodon. Described 1919, p. 95; redescribed 1922, p. 150.
Pseudorhinolophus egerkingensis. Nomen nudum 1919, p. 94; described 1922, p. 159.
Paraphyllophora. Nomen nudum 1919, p. 93; described 1922, p. 160.
Paraphyllophora robusta. Nomen nudum 1919, p. 93; described 1922, p. 160.

The names fall into three classes: (1) Those published without descriptions in 1919 but subsequently described in 1920 or 1922. These, of course, should bear one of the latter dates. (2) Those published with descriptions in 1919 and redescribed in 1920 or 1922. These should date from 1919, rather than 1920 or 1922 as the case may be. I have indicated in the list above those that are included with the wrong date in Simpson's classification of mammals (Bul. American Mus. Nat. Hist., vol. 85, 1945). (3) One published with description in 1919 (*Stehlinia*), and redescribed under another name (*Nycterobius*) in 1922. It is with the names *Stehlinia* and *Nycterobius* that the remainder of this note is concerned.

As far as I can determine, Revilliod made no mention of *Stehlinia* after 1919, and never indicated any connection between the names *Stehlinia* and *Nycterobius*. Recent authors either have overlooked *Stehlinia* or have listed both *Stehlinia* and *Nycterobius* as distinct genera.

Revilliod described *Stehlinia* and *Nycterobius* as monotypic genera. In each the species was named *gracilis*. From Revilliod's descriptions it appears that both *Stehlinia gracilis* and *Nycterobius gracilis* were based on the same specimen. The evidence in favor of this thesis is only circumstantial, but it leads inevitably to the conclusion that the two names are synonymous. In the first place, the descriptions and remarks for the two names coincide exactly. Secondly, although the museum number of the type specimen was mentioned only for *Nycterobius gracilis*, each of the species was based upon a single specimen, in each case a remarkably well preserved skull. The third bit of evidence is that *Stehlinia* and *Nycterobius* are the only names in the two publications (the monograph and the summary) for which there is not some sort of cross reference.

The primary evidence of synonymy of the two names is in Revilliod's descriptive matter. His terse 1919 description of *Stehlinia gracilis* is as follows:

"C'est dans le Quercy que l'on trouve le représentant le plus ancien de la famille des Vespertilionidés. C'est un petit crâne que je nomme *Stehlinia gracilis*, assez semblable au crâne de petites espèces de *Myotis* (*M. cappacinii*), mais s'en distinguant par quelques caractères primitifs: crâne facial très allongé, série des prémolaires relativement très longue, P^3 [P^3 in American nomenclature] à 2 racines."

For comparison with this I quote significant passages from the four page description of *Nycterobius gracilis* in the 1922 part of the monograph:

"Je crée ce nouveau genre pour un crâne appartenant au Musée de Bâle (Q. P. 602) et provenant du même gisement de phosphorite que les crânes de *Palaeophyllophora oltina* [Quercy] . . . (p. 133)."

"En effet, *Nycterobius* [Vespertilionidae], *Vespertiliavus* [Emballonuridae] et *Necromantis* [Megadermatidae] sont les genres les plus anciens de leures familles respectives (p. 181)."

"Ce petit crâne est très bien conservé . . . Par sa conformation générale, il est assez

semblable au crâne de petities espèces du genre *Myotis*, en particulier du *Myotis capaccinii*, . . . (p. 133)."

"Il s'en distingue par les caractères plus primitifs suivants: crâne facial très allongé, . . . espace entre P^1 [P^4] et C très long, . . . P^3 [P^2] à 2 racines (p. 136)."

Apparently the synonomy of *Stehlinia* Revilliod should stand as follows:

Stehlinia Revilliod

1919. *Stehlinia* Revilliod, Compte Rendu Soc. Phys. Hist. Nat. Genève, 36(3): 94. Type: *Stehlinia gracilis* Revilliod.

1922. *Nycterobius* Revilliod, Mém. Soc. Paléo. Suisse, 45: 133. (New name for *Stehlinia* Revilliod. Preoccupied by *Nycterobius* Kirby 1815, *Nycterobius* MacLeay 1832, and *Nycterobius* Freeman 1852). Type: *Nycterobius gracilis* Revilliod.

1945. *Revilliodia* Simpson, Bul. American Mus. Nat. Hist., 85: 59. (New name for *Nycterobius* Revilliod.) Type: *Nycterobius gracilis* Revilliod.—CHARLES O. HANDLEY, JR., *U. S. National Museum, Washington, D. C. Received December 18, 1953.*

MYOTIS SUBULATUS LEIBII FOUND IN UNUSUAL SITUATIONS

When one of a group of boys exploring Schoolhouse Cave, 4½ miles NE Riverton, Pendleton County, West Virginia, on January 26, 1950, heard a bat squeak in the cave floor where he was digging clay samples, he called me over to investigate. The bat was found to be in a small crevice in the clay, well out of sight, and considerable digging was required to obtain it. The animal was quite active when uncovered. The crevice contained a rather large amount of feces, indicating that possibly the bat had lived here in an active state. The specimen was preserved and identified as *Myotis subulatus leibii*.

On December 27, 1953, Christy A. Weiland and I were gathering bats for banding in Greenville Saltpeter Cave, one-half mile NE Greenville, Monroe County, West Virginia, when we heard a bat squeaking underfoot. The cave floor here was composed of small flat stones packed rather closely together. We began removing the stones and found *Myotis subulatus leibii* in torpid condition about six inches below the surface. A considerable amount of feces was found among the rocks.

I have often seen bats tucked into a crevice in the wall or ceiling of a cave, but I have never before known them to be found in a cave floor.—WAYNE H. DAVIS, *Museum of Natural History, University of Illinois, Urbana. Received January 29, 1954.*

A RECORD OF *LASIURUS* AND OF *VAMPYROPS* FROM PARAGUAY

The two specimens of my collection referred to in this note were taken by Dr. R. F. Hussey, January 4, 1932 at a ranch near Caa Guazú, Paraguay. This is about 56° W. longitude and 25° 17′ S. latitude, or about 33 kilometers south of Yhu. A description of this grazing area is given by Carvalho and Hussey (Occ. Pap. Univ. Michigan, Mus. Zool., no. 552, 1954). Each specimen is a male and consists of a skin without a skull. These were identified by Colin Campbell Sanborn as *Lasiurus cinereus villosissimus*, cat. no. 2678; and *Vampyrops* probably *helleri*, cat. no. 2677. Sanborn states that this specimen of *Lasiurus* is a topotype and the only one in this country. There are two other specimens from Paraguay in the British Museum. He also states that this is the first record for this species of *Vampyrops* for Paraguay.

Measurements taken in millimeters from the dried skins of these specimens of *Lasiurus* and *Vampyrops* are respectively as follows: forearm, measuring over elbow and wrist of folded wing, 52.3, 38.3; over wrist to end of 3rd metacarpal, 60.3, 40.4; to end of 4th metacarpal, 52.5, 39.7; to end of 5th metacarpal, 53.8, 40.8; thumb, 14, 14; tibia, 21.5, 18.5.—H. B. SHERMAN, *Department of Biology, University of Florida, Gainesville. Received December 18, 1953.*

OBSERVATIONS ON HOARY BATS IN A STORM

My neighbor Charles Miller, who resides in St. Cloud, Minnesota, captured a mother hoary bat (*Lasiurus cinereus*) on his lawn at 11:00 AM, July 7, 1951. What caused her to be

crawling on the lawn is unknown. Sunstroke seems unlikely since the temperature was only 79° F. There was little wind at the time. She may have fallen from the overhanging elm trees. Her load of two male babies weighing 9.5 and 10.1 grams respectively plus her own weight of 27.2 grams made takeoff from the lawn impossible.

After the weighing and banding operation they were placed in a cardboard box. The babies soon attached themselves to the nipples of the mother and the trio were placed on a tree trunk at head height. Takeoff was easy now, but the mother experienced difficulty gaining altitude while carrying her load. She succeeded in coming to rest on a leaf of a basswood tree 15 feet above the ground a block away. In fact she hung to this same leaf during the storm which raged from six to seven o'clock that evening. Two inches of rain fell in the hour. Wind, which rocked the trees and scattered branches in the streets, was recorded at the local weather station at up to 61 miles per hour.

Further observations revealed that the mother left the young hanging on the leaf at 8:50 PM while she went out to feed and that she returned to her family again at 11:25 PM. The next day, however, the trio were gone.—HARRY H. GOEHRING, *State Teachers College, St. Cloud, Minnesota. Received November 26, 1953.*

A CASE OF POLYDACTYLY IN THE COLUGO, *CYNOCEPHALUS*

The occurrence of additional digits is well known in mammals and the genetics of such anomalies has been extensively studied in man and laboratory animals (Gates, HUMAN GENETICS, 1946). In animals such as the guinea-pig, where the number of digits has undergone reduction during the course of evolution, the appearance of extra digits may in some instances be regarded as a reversion to ancestral conditions (Stockard, Amer. Jour. Anat., 45: 345–375, 1930). In forms such as man and *Cynocephalus*, which normally possess pentadactyl limbs, this question does not arise. Polydactyly in such forms cannot be interpreted in terms of phylogeny and is comparable with other examples of reduplication which sometimes involve various organs.

In most cases of polydactyly the digit involved is either the first or the last on the extremity so that a classification of the condition into pre- and postaxial polydactyly can be made. The anomaly is often bilateral and usually the extra digit is fused with its neighbour

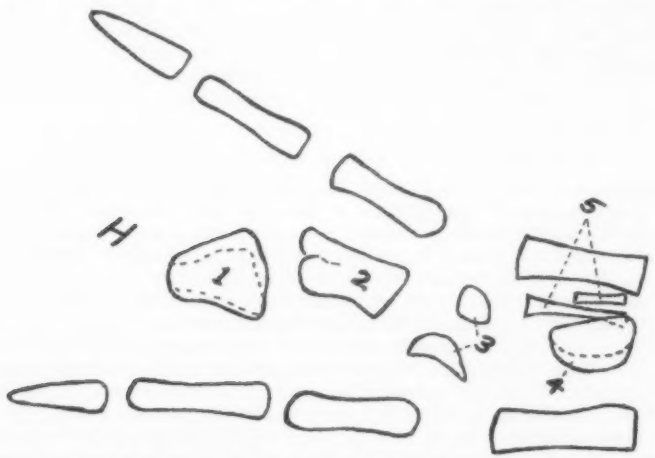

FIG. 1.—Enlarged outline drawing of X-ray of bones of first three digits on right (anomalous) pes. Interrupted lines illustrate presumed reduplication of phalanges of hallux (H). See text for explanation of numerals.

over some part of its extent. The case of unilateral polydactyly described is of interest in that a complete, separate extra digit is present. It is, moreover, most unlikely that other examples of polydactyly in *Cynocephalus* (= *Galeopithecus*) have come to notice.

The anomalous specimen is an immature male *Cynocephalus volans*, measuring approximately 180 mm. from the snout to the tip of the extended tail. This, two other more mature specimens, and an adult skeleton in the departmental collection are believed to have come from Sarawak; further details of their provenance are not known. The specimen described is the only one that shows anomalies.

On external examination the right pes was seen to possess six digits. The digit on the preaxial side of the extremity corresponds in length with the four postaxial digits and bears a normal claw. The second digit conforms in length and appearance with the hallux of the opposite side. Dissection shows that both these digits possess flexor and extensor tendons similar to those of the other digits, and were presumably functional.

In X-ray photographs it was seen that the bones of both feet were incompletely ossified, the os calcis being the only tarsal visible. No bony epiphyses were apparent in any part of the hind-limb skeleton. The left foot showed no abnormal features.

The first of the six digits on the right foot (Fig. 1) consists of three phalanges and a metapodial which are well formed and show no suggestion of reduplication. This digit is interpreted as the extra one, situated on the preaxial border of the foot.

The second digit, which is regarded as the right hallux, shows anomalies which are not apparent in its external appearance. Close examination of the X-ray suggests that the broad terminal phalanx (1, in Fig. 1) is partly reduplicated. The next phalanx (2) shows evidence of partial reduplication also; it lies in line with the proximal phalanges of the other digits and corresponds in position with the proximal phalanx of the hallux on the left side. Next lie two small crescentic bones (3) which are quite separate from each other. More proximally still, and more or less in line with the metatarsals of the other digits are three elements. One (4) is short and broad and probably reduplicated. The other two (5) are very slender; the outer one is by far the shorter.

The elements of such an anomalous digit cannot be identified with certainty. It is probable, however, that the two most distal bones (1 and 2 in Fig. 1) represent the proximal and distal phalanges which are normally present in the hallux. The three most proximal elements (4 and 5) probably represent the whole or parts of the metatarsal, while the two crescentic bones (3) may either represent the distal part of the metatarsal, or an additional phalanx. In the latter contingency a condition of polyphalangy, in addition to polydactyly, would be present. Our thanks are due to Mr. J. A. Fairfax Fozzard for taking X-ray photographs.—C. C. D. Shute and A. d'A. Bellairs, *University Department of Anatomy, Cambridge, England.* *Received February 1, 1954.*

A RECENT RECORD OF LYNX IN MICHIGAN

For a number of years the status of the lynx (*Lynx canadensis*) has been a matter of conjecture in Michigan. Burt (THE MAMMALS OF MICHIGAN: 168, 1943) reports them formerly throughout the state with the last record coming from Isle Royale. Since that time the lynx has been considered extinct, or virtually so, in Michigan, with the possible exception of Isle Royale and even here it is of questionable occurrence.

Recently Lloyd Schemenauer, game biologist, and the writer had occasion to inspect a lynx killed near Barbeau, Chippewa County, Michigan. The animal, a male, was shot November 7, 1953 by Mr. Elmer Gregg when treed on his farm by dogs. It reputedly weighed 26 pounds. The animal's green pelt was examined but measurements, other than pelt lengths, could not be taken. These were nose to tail tip, 4 feet, and nose to hind foot, 5 feet 5 inches. A middle toe was missing from its right front paw, testimony of its encounter with a trap at some much earlier date, as the foot was well healed. Fortunately the carcass was obtained. Small mammals had eaten much of its flesh but the skeleton was largely intact, with the exception of the skull which was damaged by a rifle bullet. These remains are to be preserved in the University of Michigan Museum.

The presence of this lynx in Michigan is probably explainable as an immigrant from Ontario, Canada, which is within sight across the St. Marys River from the point the animal was taken. Its having been killed on November 7, 1953 precludes the possibility of its having crossed the ice later than April, 1953, which would indicate its having been in Michigan at least seven months.—ALBERT W. ERICKSON, *Cusino Wildlife Experiment Station, Shingleton, Michigan. Received February 4, 1954.*

FALSE HEAT IN THE YEARLING COYOTE, *CANIS LATRANS*

James Simon took two coyote pups from a den in 1951 to his home in Moran, Wyoming, where they ran free but stayed about the yard. In September we brought the female to Swarthmore with us. She lived in the cellar, part of which was unexcavated, but was brought up several times a day to play outside on a leash or to play free in the house. She was so friendly and gentle that we could handle her freely. Outdoors she played with the neighbors' children and with their dogs, while indoors she played with us or our dog.

On February 22 her vulva began to swell and on February 27 there was a slight sanguineous discharge. The vulva was 27 mm. in diameter at the base and 18 mm. high. The discharge was observed on the 28th also. When exposed to an experienced stud dog the dog smelled her vulva a few times but did not attempt to mount her. They were perfectly friendly. The sanguineous flow continued for another day. The vulva remained turgid for six days and then receded. Although exposed every day to the stud dog the dog never attempted copulation. On the other hand a younger dog attempted copulation daily during the entire period but the coyote never responded either by crooking her tail or standing. She played very willingly with this dog but without displaying an interest in breeding. She dug in the unexcavated part of the cellar but made no attempt to construct a den. Failure to breed may indicate that under conditions of semi-domestication the coyote does not come into full heat during her first year. One must also consider the possibility that the stud dog was growing old and did not have the energy or interest to tease the coyote into copulation. This is unlikely for he was a skillful sire. The younger dog was a cocker spaniel and, therefore, rather too short for copulation with a coyote although he tried. Since other dogs in the neighborhood showed no great interest in the spots where the coyote urinated when out of doors, we reached the conclusion that, although there was a bloody discharge and the vulva swelled, not enough hormones were produced to bring about full sexual activity. Moreover, she showed none of the signs of pseudo-pregnancy such as are seen in bitches that have come into full heat but have not become pregnant.—ROBERT K. ENDERS, *Swarthmore College, Swarthmore, Pennsylvania. Received February 26, 1954.*

A RECENT RECORD OF THE MARTEN IN MINNESOTA

An authentic record of a pine marten (*Martes americana*) in Minnesota was noted on December 3, 1953, when Waino Starkman of Ely, Minnesota, brought a marten pelt to local game wardens. The animal had been caught accidently in a bobcat trap set near Burntside Lake (T 64 N, R 13 W), St. Louis County, in the Superior National Forest in northeastern Minnesota. The pelt measured 28½ inches from the tip of the nose to the end of the skin in the tail. The tail measured 7 inches. Unfortunately, the carcass was destroyed.

No authentic records of marten have been noted for at least thirty years in Minnesota. Earlier records show that a fur company purchased 200 Minnesota skins between 1860 and 1890 and that 96 were purchased in Crow Wing County in 1871. In 1894–95, 43 marten were reported trapped in the Caldwell Brook country of Koochiching County along with four fisher. Marten were reported as "very scarce" in St. Louis County by 1920 and were dropped from U. S. Forest Service records in 1919. Apparently the last authentic record of a marten in Minnesota was in 1920 when Adolph Hodap trapped his last marten in the Northwest Angle, the most northerly projection of the United States on the north side of Lake of the Woods.—MILTON H. STENLUND, *Minnesota Division of Game and Fish, St. Paul. Received January 29, 1954.*

BLOOD PICTURE OF THE AMERICAN BLACK BEAR, *URSUS AMERICANUS*

In conjunction with an investigation of the blood picture of various hibernating mammals, a male American black bear (*Ursus americanus*) was made available for study through the courtesy of Edward Johnson, superintendent of the Woodland Park Zoological Garden, Seattle, Washington. The bear, weighing 211 pounds, was successfully anaesthetized using "Nembutal" as a sedative on three separate occasions, August 10, August 21, and September 27, 1951, without any visible deletereous after-effects.

TABLE 1.—*Blood picture of the American black bear*

	August 10	August 21	Sept. 27
RBC	8,700,000	5,490,000	7,250,000
WBC	12,550	13,750	11,750
Hgb	17.82	13.74	14.90
Hemat	33	—	37.5
Blood volume, cc	6,145*	9,230*	8,323
Blood volume, %	6.42*	9.62*	8.71
Clotting time	7′ 40″	11′ 20″	—
Glucose	59.2	92.5	—
NPN	40.5	32.7	—
Cholesterol	305	325	—

Not taken

* Due to technical difficulties encountered during sampling the figures for blood volumes and blood volume percentages obtained on August 10 and August 21 may not be as accurate as those secured on September 27.

TABLE 2.—*Results of differential examinations of blood cells in the black bear*

Date	Myel	Meta	Band	Neutrophils segment				Eosin	Baso	Lymph	Mono
				2	3	4	5				
8–21	1	6	51	19	0	1	0	14	0	5	3
9–27	0	1	25	24	21	5	0	2	0	20	2

TABLE 3.—*Blood pictures of man and black bear compared*

	Man*	Black bear
RBC	4,800,000 (Female) 5,400,000 (Male)	5,490,000 8,700,000 Average 7,147,000 7,250,000
WBC	7,000	12,550 13,750 Average 12, 687 11,750
Hemat	47	33 37.5
Hgb.	14–16	13–14
Clotting time	6′ to 15′ (Lee and White)	7′40″ to 11′20″
Blood volume, cc	4,700 (Male) 3,500 (Female)	8,323
Blood volume, %	6 to 9.3	8.71

* Data taken from Wintrobe "Clinical Hematology"

Blood was obtained from the saphenous veins. The erythrocyte, leucocyte and differential counts as well as hematocrit and hemoglobin determinations were made by the usual methods. The blood volumes were obtained by the Keith, Rowntree and Geraughty plasma dye dilution technique. Clotting times were determined by Lee and White's method. Folin-Wu's method was used to determine the glucose content. The cholesterol was ascertained by Sackett's technique and NPNs by Rappaport's procedure.

Acknowledgement is made to Air Force Contract AF 33(038)-18509 for aid and assistance in making this study. Table 1 shows the data obtained. The results of the differential examinations are shown in Table 2. The blood cells of this bear were very similar to those of man except that the neutrophils contained numerous lipid (?) inclusions.

A comparison of the blood picture of this bear with that of man is presented in Table 3.

An analysis of the blood picture of these two mammals shows that the black bear has a greater erythrocyte and leucocyte number than man, a lower hematocrit volume but apparently the same hemoglobin content. The black bear has a greater blood volume in actual amount but the percentages per body weight of the two are similar, as well as the clotting times of the blood.—Arthur Svihla, Howard Bowman, and Roger Pearson, *Department of Zoology, University of Washington, Seattle.* *Received November 23, 1953.*

BLOOD VOLUMES IN THE GOLDEN HAMSTER

Since the golden hamster (*Mesocricetus auratus*) has become an important addition to the group of mammals that are used extensively in laboratory research, pertinent data relating to its morphology and physiology are of importance. Stewart, Florio and Mugrage (Jour. Exp. Med., 80: 189, 1944) have given a very detailed account of various cellular components of the blood of the hamster, but do not include or determine the blood volumes.

Acknowledgment is made to Air Force Contract AF 33(038)-18509 for aid and assistance in making this study. Using Cartland and Koch's (Amer. Jour. Physiol., 85: 540, 1928) micromodification of the Keith, Rowntree and Geraghty (Arch. Int. Med., 16: 547, 1915) plasma dye dilution technique, the blood volumes of nine active hamsters were obtained. The data are presented in Table 1.

These data show that the average blood volume in active hamsters is 6.63 cc. or slightly more than 7.4 per cent of the animal's weight.

The following percentages of blood volume to body weight of various mammals, taken from Scarborough (1930), are arranged according to the increasing size of the adult animals: mouse, 8.91 to 9.03; hamster, 7.44; guinea pig, 4.1; rat, 6.3; ground squirrel, 10.0; cat, 5.5; rabbit, 5.8; dog, 9.2; and man, 6.0 to 8.0. The hamster, which is intermediate in size between the mouse and the rat, has a blood volume percentage also intermediate. Nevertheless its

Table 1.—*Blood volumes of active hamsters*

Animal number	Weight	Blood volume, cc.	Blood volume, %
17	73.2	6.03	8.23
14	73.9	5.93	8.10
11	92.2	7.20	7.81
10	77.3	6.08	7.87
6	102.8	7.92	7.69
3	112.9	7.02	6.22
19	94.7	6.38	6.74
21	89.0	5.68	6.38
22	93.8	7.49	7.97
Average	89.96	6.63	7.44

blood volume percentage is greater than that of either the cat or rabbit both of which are larger in size.—Arthur Svihla and Howard Bowman, *Department of Zoology, University of Washington, Seattle.* *Received January 8, 1954.*

HAIRLESS SQUIRRELS

During the regular November small game season (1953) a hunter in McKean County, Pennsylvania, shot and killed a litter of four, almost hairless, red squirrels *Tamiasciurus hudsonicus*. The major portions of the bodies of these squirrels were naked, but tufts of hair were present around the four feet, the head, and the end of the tail. A cursory examination suggested that no hair had ever been present on the naked skin thus indicating a genetic factor.—Roger M. Latham, *Pennsylvania Game Commission, Harrisburg, Pennsylvania.* *Received March 20, 1954.*

THE OCCURRENCE OF *TAMIAS STRIATUS* IN GEORGIA

The eastern chipmunk is relatively abundant in the northern part of the state and does not occur below the 34° latitude (Anthony, FIELDBOOK OF NORTH AMERICAN MAMMALS, 1928). Hamilton (THE MAMMALS OF EASTERN UNITED STATES, 1943) depicts the southernmost range of this chipmunk in Georgia on a map as being a line drawn from the 33° latitude on the western side of the state to a point at approximately the 34° latitude on the eastern side. More recently Burt and Grossenheider (A FIELD GUIDE TO THE MAMMALS, 1952) show the southern extension of *T. striatus* in Georgia to approximate the limits set by Hamilton except that Burt has seemingly moved the western side more northerly.

In any event a line drawn from the 33° latitude on the western side to the 34° latitude on the eastern side passes fifty miles north of Rivoli, Bibb County. Of interest then is the fact that a living male specimen of *Tamias striatus* was taken on the Wesleyan College campus, Rivoli, Bibb County. In addition several wild specimens have frequently been seen atop a hardwood-covered hill on the campus. This breeding population extends this chipmunk's southern range about fifty miles.—James C. Knepton, Jr., *Department of Biology, Wesleyan College, Macon, Georgia.* *Received November 10, 1953.*

TAXONOMIC STATUS OF GROUND SQUIRRELS, *CITELLUS LATERALIS* (SAY), FROM NORTHEASTERN UTAH AND NORTHWESTERN COLORADO

When Howell (North Amer. Fauna, 56, May 18, 1938) revised the ground squirrels of North America, he assigned a specimen of *Citellus lateralis*, number 10807/9104, American Museum of Natural History, from eastern Utah, collected May 6, 1895, by W. W. Granger, to *Citellus lateralis wortmani* (Allen). Kelson (Univ. Utah Biol. Ser., 11(3), February 15, 1951) and Durrant (Univ. Kansas Publs., Mus. Nat. Hist., 6, August 10, 1952) did not recognize the name combination *Citellus lateralis wortmani* as applying to any animals from Utah. Neither Kelson nor Durrant examined this single specimen that Howell (*op. cit.*) had assigned to *C. l. wortmani*. They did examine, however, specimens from the same general region and found them all to be referable to *C. l. lateralis*. Howell (*op. cit.*: 195) also assigned specimens from the lower drainage of the Little Snake River, where it parallels the Wyoming-Colorado boundary, to *C. l. wortmani*, but assigned other specimens from farther west, in western Moffat County, Colorado, to *C. l. lateralis*. This assignment of the specimen from Utah to *C. l. wortmani* divided the range of *C. l. wortmani*. Howell (*op. cit.*: 192), however, did not show this division in his distribution map. Warren (The Mammals of Colorado, Univ. Oklahoma Press, 122, 1942) referred specimens from both western Moffat County and from along the Little Snake River, Routt County, Colorado, to *C. l. wortmani*. Warren (*op. cit.*) agreed with Howell that specimens from Douglas Spring in the Escalante Hills, only a few miles west of the Little Snake River, were referable to *C. l. lateralis*.

In our study, we have examined specimens from western Colorado from the following localities: Rio Blanco, Rio Blanco County; White River, 20 miles east of Rangely, Rio Blanco County; 5 miles west of Rangely, Rio Blanco County; Douglas Spring, Moffat

County; 20 miles east of Ladore, Escalante Hills, Moffat County; Rifle, Garfield County; Little Snake River, Routt County. In addition, we have studied topotypes of *C. l. lateralis* and *C. l. wortmani*. As concerns the Coloradan specimens, we are in agreement with Howell. All specimens from western Colorado that we have studied, except those from Little Snake River, Routt County, are referable to *C. l. lateralis*; those from the latter locality are referable to *C. l. wortmani*. These latter animals while being referable to *C. l. wortmani* are intergrades between that subspecies and *C. l. lateralis*. In color, they are pale, but are not so light as topotypes of *C. l. wortmani*. Cranially, with the exception of slightly shorter nasals, these specimens from Little Snake River could be assigned with equal propriety to either *C. l. wortmani* or *C. l. lateralis*. All other specimens from western Colorado examined by us are definitely referable to *C. l. lateralis*. Some of them are as dark as topotypes of *C. l. lateralis*, while none is so light as topotypes of *C. l. wortmani*. Even the palest specimens are not beyond the range of individual variation of specimens known to belong to *C. l. lateralis*. Cranially, these animals are indistinguishable from topotypes of *C. l. lateralis*.

The aforementioned specimen from Utah merits special consideration. This specimen was assigned to *C. l. wortmani* by both Allen (Bul. Amer. Mus. Nat. Hist., 7: 242, November 25, 1896), and by Howell (*op. cit.*: 56). According to Granger's notes as interpreted by Allen, this specimen was from a locality known as Kennedy's Hole, 10 miles west of the Utah-Colorado boundary. The specimen bears only the locality record "Unconpahgre [Uncompahgre] Indian Reservation, Utah." Allen's writings on this specimen are somewhat ambiguous. In his report (*op. cit.*: 242) it is inferred that this specimen came from Kennedy's Hole. In another place in the same paper (*op. cit.*: 255), under the separate species accounts, no mention is made of this animal. Earlier, in his description of *Citellus wortmani*, Allen (Bul. Amer. Mus. Nat. Hist., 7: 335, November 8, 1895), again made no mention of this animal from Utah. We are of the opinion, after having visited the area three times, that this specimen was not obtained from Kennedy's Hole proper, but possibly came from along the Green River or the White River which are respectively west and south of Kennedy's Hole. Records of occurrence and our observations lead us to conclude that golden-mantled ground squirrels only occur in this general area along streams where there are rocky outcroppings. Kennedy's Hole is a bad-land basin that drains due west and joins the White River about 8 miles east of Ouray, Utah. The name was attributed to a freight station that was located approximately 8 miles north northwest of Bonanza, Utah. The basin has no permanent water and is bordered on all sides by hills that are sparsely covered with juniper pinyon trees. No habitat suitable to these squirrels is found in this basin at present.

This specimen from Utah, which has been referred to *C. l. wortmani* does not belong to that subspecies. It belongs to *C. l. lateralis*. It is a young adult female, one-half through the annual molt. In general color, it is pale and does resemble topotypes of *C. l. wortmani*. This pale coloration probably influenced earlier workers to refer it to *C. l. wortmani*. This pale overall coloration is found in individual specimens from throughout the range of *C. l. lateralis*. Critical analysis of the color of this single specimen shows the following: Underside of tail yellowish as in the majority of specimens of *C. l. lateralis*; upperparts and rump darker than in *C. l. wortmani*; underfur dark as in *C. l. lateralis*. As concerns the cranial details, this specimen is intermediate between the two subspecies in the size of the tympanic bullae. It resembles topotypes of *C. l. lateralis* in the shape of the nasals, and in the extension of the nasals beyond the fronto-premaxillary suture. The length of the nasals is like that in *C. l. wortmani* (in topotypes of *C. l. wortmani*, some appear to have had the ends of the nasals cut off, as does this single specimen from Utah).

We have studied golden-mantled ground squirrels from the near vicinity of Kennedy's Hole and they are all referable to *C. l. lateralis*. We, therefore, do not consider the name combination *Citellus lateralis wortmani* as applying to any animals from Utah. Moreover, our studies indicate that animals of the subspecies *C. l. wortmani* are restricted to the type locality and immediate environs.

For the loan of comparative material, we are indebted to A. C. Rogers and Alfred M. Bailey, Denver Museum of Natural History, Denver, Colorado; Robert M. Stabler, Colo-

rado College, Colorado Springs, Colorado; George G. Goodwin, American Museum of Natural History, New York City, New York; Viola S. Schantz and John Aldrich, United States National Museum, Washington, D. C.; E. R. Hall, Museum of Natural History, University of Kansas, Lawrence, Kansas; W. H. Burt, Museum of Zoology, University of Michigan, Ann Arbor, Michigan; J. K. Doutt and C. A. Heppenstall, Carnegie Museum, Pittsburgh, Pennsylvania.—STEPHEN D. DURRANT AND RICHARD M. HANSEN (*U. S. Public Health Service Fellow, Microbiological Institute*), *Department of Vertebrate Zoology, University of Utah, Salt Lake City, Utah.* *Received February 8, 1954.*

MUSKRAT REMAINS FROM A PREHISTORIC INDIAN SITE IN JACKSON COUNTY, FLORIDA

In 1953 the junior author conducted archeological investigations in the Chattahoochee River Valley of northern Florida. Among the animal remains recovered from Indian sites was the lower left ramus of a muskrat, *Ondatra zibethica*. It was collected from Level 9 at Site J-5 (field number), about three miles east of Sneads, Jackson County, Florida. This region and its archeology have been considered in a previous paper (Bullen, Jour. Wash. Acad. Sci., 40: 101–125, 1950).

The jaw is larger than that of *Neofiber alleni*; the molar tooth row measures 15.8 mm. in length. Identification was checked by Dr. H. B. Sherman, of the Department of Biology, University of Florida; and also by H. James Gut, of Sanford, Florida. The specimen (Catalog No. 92571) is now in the Florida State Museum at Gainesville.

The muskrat jaw was associated with both fiber-tempered and St. Johns (chalky) pottery. This particular ceramic combination implies a dating of about 500 B.C. The muskrat has not been reported previously from this time level in Florida. Other remains from the state are thought to be of Pleistocene age (Simpson, Amer. Mus. Nov. No. 406, 1930).—WILFRED T. NEILL AND RIPLEY P. BULLEN, *Research Division, Ross Allen Reptile Institute, Silver Springs, Florida, and Florida State Museum, Gainesville.* *Received January 29, 1954.*

NOTES ON THE FLORIDA PINE MOUSE, *PITYMYS PARVULUS* HOWELL

The Florida pine mouse, *Pitymys parvulus*, has been reported but a few times, and little is known of its biology. Thus it seems worthwhile to record the collection of three additional specimens.

The type locality of this mouse was originally given as Ocala, Marion County, Florida (Howell, Proc. Biol. Soc. Wash., 29: 83–84, 1916). However, it was later corrected to the vicinity of Lynne (Lynn), about 13 miles east of Ocala (Howell, Jour. Mamm., 15: 72, 1934). The present specimens were taken about two miles east-southeast of Lynn, and may therefore be considered topotypes.

The mice were found in an ecotone between two plant associations, rosemary scrub and high pine. The locality is one of deep sand, with scattered trees, little underbrush, and practically no humus. The trees are mostly sand pine (*Pinus clausa*) and turkeyoak (*Quercus catesbaei*). The former is characteristic of rosemary scrub, the latter of high pine. The two trees do not occur together in any numbers, except where one of these associations is passing into the other. Since the type specimens were collected in an area of "sand pine and scrub-oak" (i.e., turkeyoak), they too evidently inhabited an ecotone.

On August 20, 1953, the authors were collecting reptiles at the aforesaid locality, and chanced to roll a large sand pine log. Beneath the log was a mouse nest. Within an inch or two of the nest were two adult *Pitymys*, one of them a female with a single nursing young. The mice attempted to escape, but were unable to do so, for the rolling of the log had exposed and disturbed a good bit of their runways. The young one did not relinquish its grip on the female's teat until after the mice had been placed in a jar.

The collector of the type series described a Florida pine mouse nest as being made of palmetto bark, lined with a silky, fibrous material like the inside of a milkweed pod. The nest found by the authors was much less elaborate. It was merely a saucer-shaped mass of rootlets and small grass blades. However, this material was quite soft and moist. Rootlets

and blades appeared to be those of "broomsedge" (*Andropogon* sp.), a common plant in the vicinity. No seeds or other food items were noted about the nest.

The runways were approximately three-quarters of an inch in diameter. They formed an elaborate network, about one inch below the surface, near the base of a large turkeyoak. All the runways within 15 to 20 inches of the nest were thick with cut bits of turkeyoak leaves. This decaying leaf debris must go far to provide the rodents with a moist microhabitat.

In both scrub and high pine, even hard rains soak rapidly into the deep, loose sand; the upper few inches of soil are quite dry much of the time. At the present locality, the leaf scrap formed a damp oasis in the dry sand. This scrap could easily have been overlooked as debris from the rotting log, or could have been mistaken for ground litter upon which the timber had fallen. Close observation revealed that the leaves had all been cut into bits, most of them no bigger than a fingernail.

One of the adults, after having been placed in a jar, voiced a chattering call of four or five notes in rapid succession. The gait of the Florida pine mouse was observed to be quite shrew-like. Indeed, this rodent is remarkably similar to a shrew in several superficial aspects of appearance, and in some of its habits.

The three topotypes were given to Dr. H. B. Sherman, of the Department of Biology, University of Florida.

The senior author has previously expressed the opinion that many supposed rarities actually are abundant, being merely difficult to collect by standard techniques (Neill, in press). This is probably the case with *Pitymys parvulus*. At night, after really torrential rains, these rodents sometimes appear on roads. The senior author has thus noted them on several occasions along Florida State Highway No. 40, in the Ocala National Forest. Five or six highway casualties, much flattened but nevertheless identifiable, have been seen in this area. It should be noted that the *Pitymys* are not brought forth by ordinary summer rains, but only by exceedingly hard, prolonged downpours. Such rains occur about once or twice a year, and are often accompanied by winds that approach hurricane velocity.

Small runways can be found beneath logs in almost any dry patch of rosemary scrub or high pine throughout Central Florida. Such tunnels are exactly like those known to be made by the Florida pine mouse. Other small rodents, notably *Peromyscus polionotus* and *P. floridanus*, occur in scrub and high pine, but they construct very different burrows from those of *Pitymys parvulus*. As far as the authors know, the shrews of the region, *Cryptotis parva* and *Blarina brevicauda*, are not found in areas where humus is lacking. Thus it seems likely that the pine mouse is responsible for many of the runways observed. These burrows, possibly attributable to *Pitymys parvulus*, have been noted in Alachua, Levy, Putnam, Marion, Lake, Orange, and Polk counties, Florida.—Wilfred T. Neill and James M. Boyles, *Research Division, Ross Allen Reptile Institute, Silver Springs, Florida, and Department of Biology, University of Alabama, Tuscaloosa.* *Received December 18, 1953.*

THE EFFECT OF COLD STARVATION UPON CARBOHYDRATE RESERVES IN *PEROMYSCUS MANICULATUS*

It has been determined by Howard that small rodents can withstand prolonged exposure to freezing temperatures only if sufficient food is available (Jour. Mamm., 32: 300–312, 1951). Sealander (Amer. Mid. Nat., 46: 257–311, 1951 also found that *Peromyscus* when exposed to freezing temperatures without food would die within several hours with little loss in body weight. In this laboratory it has been found that so long as sufficient food is available wild adult *Peromyscus maniculatus* would survive in a refrigerator maintained at zero degrees centigrade for as long as six weeks when confined in individual cages with no nesting material. The diet consisted of a mixture of rolled oats, peanut butter, dried milk, pork liver, and chopped apple. If the food was withdrawn they would begin to die within several hours. This suggests that these small rodents cannot convert protein or fat into oxidizable substrate fast enough to meet the increased metabolic requirements imposed by cold starvation. The following experiments were conducted to determine the effect of starva-

tion and cold starvation upon liver glycogen and blood glucose in wild adult *Peromyscus maniculatus*.

In the following experiments, the animals were anesthetized with ether at the time of sacrifice and the blood sample was obtained by heart puncture. With the animal still alive but anesthetized, the abdomen was opened, and the whole liver was removed, weighed, and dissolved in hot 30 per cent potassium hydroxide. The blood glucose was determined according to the method of Somogyi (Jour. Biol. Chem., 160: 61, 1945) and converted to milligrams per hundred cubic centimeters. The liver glycogen was determined according to the methods of Good, Kramer and Somogyi (Jour. Biol. Chem., 100: 485, 1933) and converted to milligrams per gram of liver.

Controls.—One group of eight animals was fasted for 12 hours and then fed the above diet. All were observed to eat. Two hours later these animals were sacrificed and the liver glycogen and blood glucose levels determined. The mean liver glycogen in this group was 20.03 milligrams per gram, and the mean blood glucose level was 106.8 milligrams per 100 cubic centimeters.

Cold starvation.—Twenty animals were fasted for twelve hours, placed in individual cages and exposed in the refrigerator maintained at zero degrees centigrade. In 5.9 hours 50 per cent of the animals had succumbed and the remaining animals were then sacrificed. The mean liver glycogen level in this group was 0.779 milligrams per gram of tissue. However, there was no detectable glycogen in two of the liver samples. The mean blood glucose level was 24.8 milligrams per 100 cubic centimeters.

Starvation for 24 hours at room temperature.—A group of ten animals was treated as the above group except that it was kept through the twenty four hour period at room temperature. There were no mortalities. After the twenty-four hour starvation the mean liver glycogen level was only 1.67 milligrams per gram of liver tissue. This is only slightly higher than the liver glycogen level of the cold starved animals. However, the blood glucose level of the room temperature starved group was 74.3 milligrams per 100 cubic centimeters of blood. This is nearly three times as great as the blood glucose level of the cold starved group and indicates that one of the primary effects of cold starvation is a severe, rapidly developing hypoglycemia.

Effect of Cortisone.—Selye (STRESS, 1950) has reviewed the effects that adrenal glucocorticoids show in increasing blood glucose and liver glycogen from non-carbohydrate precursors. More recently Baccus *et al.* (Proc. Soc. Exp. Biol. and Med. 79: 648–650, 1952) have shown that in the fasted white mouse a subcutaneous dose of cortisone of 40 milligrams per kilogram of body weight will cause a significant increase of liver glycogen within four hours. This suggests that during cold starvation exogenous cortisone might increase survival by providing additional carbohydrate.

Twenty animals were fasted for twelve hours and then given a subcutaneous injection of cortisone. (The cortisone used in this experiment was supplied by Merck & Co., Rahway, New Jersey.) The dose was 50 milligrams per kilogram of body weight. They were then placed in the refrigerator and checked for survival time. Fifty per cent of the animals had succumbed within 5.4 hours. This 50 per cent survival time was even less than that for the nontreated animals which was 5.9 hours. The mean glycogen level for the survivors was 1.43 milligrams per gram of liver tissue and the blood glucose level was 38.7 milligrams per hundred cubic centimeters of blood. When compared to the untreated animals these values may represent an increase in gluconeogenesis in the cortisone treated animals. However, it is apparent that supplying the animals with this additional cortisone did not increase survival time.—PAUL S. ESKRIDGE AND ROBERT H. UDALL, *Department of Physiology, Colorado Agricultural and Mechanical College, Fort Collins.* *Received March 26, 1954.*

NOTES ON THE CAROLINIAN JUMPING MOUSE IN CONNECTICUT

This smaller subspecies, *Zapus hudsonius americanus*, has been little reported or recorded in Connecticut. As far as I know this is the first record of *americanus* reported in Connecticut from North Guilford. Since it is one of the lesser known zapodids, all information seems worthy of note.

This male specimen was collected on September 21, 1952, by Mr. Kenneth Anderson in a potato hill in a cultivated field. The field was bordered on the north and south sides by hedge rows. Beyond the hedge rows were hayfields. On the east the field was bordered by a mixed wood (red cedar, dogwood and maple) in the 10–20 year age class, and on the west by a similar younger wood with gray birch added. The nearest water was an intermittent stream at approximately 200 yards.

This specimen was dug up in its hibernating sleep on a clear, bright, sunny day. The nest, which was destroyed in the process, was estimated at between six and eight inches below the surface. The mouse was observed to be torpid.

The following measurements of this male specimen are given in millimeters: total length, 183; tail, 115; and hind foot, 29. This specimen is in the Vertebrate Zoology collection at the University of Connecticut.—SYDNEY S. WALTON, JR., *41 Alexander Avenue, White Plains, New York.* *Received February 24, 1954.*

TECHNIQUES OF SEXING BEAVER, *CASTOR CANADENSIS*

Mammalogists and game managers recognize that male and female beaver show no external evidence of sexual dimorphism, with the exceptions of females that are lactating or about to give birth. Under such conditions the four pectoral mammae are prominent. The sex of a beaver can be determined by various methods of examination, internal and external. One way is to spread the lateral lips of the single excretal opening or vent and examine the common anal-urino-genital vestibule or cloaca. Anterior to the anus two openings can be found in the female and only one in the male in addition to the paired openings of the castor glands. I have found that in young females the hymen obscures the vaginal opening making the sexing of such individuals difficult when using this technique.

One can also insert a lubricated finger forward into the urino-genital region and palpate for the presence or absence of the penis. The baculum or os penis gives it an unmistakable rigidity. Bradt (1938) and Townsend (1953) sexed beaver by inserting a finger into the genital opening, but were unable to do so in animals less than one year old. I have experienced the same difficulty.

These techniques have been thoroughly discussed and illustrated by Young (1936). They are workable within limits and they require considerable restraint of the captive. The author (Young, *loc. cit.*) recommended plunging the beaver headfirst into a cast iron pipe of suitable dimensions and having an assistant hold the animal by the tail.

Another method appears to be well known (Denney, 1950; Grasse and Putnam, 1950) but undescribed prior to Rasmussen and West (1943). This is external palpation for the presence or absence of the os penis. It can be done by placing the thumb and forefinger immediately posterior to the pubic symphysis and passing them back toward the vent between the castor glands. The beaver can be held by an assistant or placed in a sack to prevent forward movement. The animal should be in a normal position with all feet on the ground. In such a position the beaver usually becomes relaxed, especially if the head is covered. The operator need only lift the tail and place the fingers in the proper position. However, he must be careful not to misinterpret concretions in the castors. Another difficulty lies in the variability of the position of the penis. It may be at one side and in close proximity to the castors in old males. Some transplanting agencies inject beaver with Nembutal prior to palpation, which to me appears unnecessary.

I have been able to sex beaver of all ages by external palpation, even young removed from pregnant females. Kits and yearlings are especially simple to sex because of the smallness of the castors and the fact that in young males even though the penis is small it is always in a median position.

Osborn (1949) developed a technique of palpation for the presence or absence of the testes. According to Young (*loc. cit.*) the testes are not evident and cannot be palpated in the living specimen. With the beaver in a normal position as described above, place one hand so that it lies lateral to the pubic symphysis with the finger tips anterior to the pubis and resting on the soft abdomen. Press lightly and draw the hand posteriorly. If the animal is a male, the testis can be felt as it slips anteriorly under the finger tips. This method is

not only cleaner, but easier in the case of beaver that are very fat or have very large castors. The use of both methods of external palpation as a double check is foolproof. Grasse and Putnam (*loc. cit.*) consider palpation of the testes to be supplemental, but not conclusive. Owen (1868) stated that the testes usually are lodged in subcutaneous depressions between the castor bags, but that the usual wide opening of the tunica vaginalis permits easy return of the gland into the abdomen. Osborn (1953) has observed that the testes may be either inguinal or abdominal in position, at least during the summer. In either position they are easily palpated.

There may be certain behavioral aspects which would enable one to distinguish between the sexes, at least in mature individuals. Old males appear more aggressive than females and younger individuals, especially after a long dry ride from the holding pen to the place of release. On several such occasions I have experienced considerable difficulty in driving old males into the water. According to Bailey and Hendee (1926) the Eskimos claim to be able to distinguish the sexes of beaver in the water because the males swim with the head held high, while the females slide along almost submerged.

The sexing of fetuses has been a subject of confusion. Grinnell *et al.* (1937) described and illustrated a beaver fetus with white pectoral spots as being a female and maintained that the absence of these spots indicated a male. Cook and Maunton (1949), upon dissection of five fetuses that were almost full term, found that two of them were males although all had white pectoral spots. I have examined 64 fetuses in various stages of development and confirm Cook's and Maunton's observations.

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Dale J. Osborn, *Department of Biology, Boston University, Boston, Mass.*

NORTHERN EXTENSION OF RANGE OF POCKET GOPHER EAST OF THE MISSISSIPPI

Pocket gophers in Wisconsin are known to occur in the west-central part of the state (Mentor Township, Clark County, and Anson Township, Chippewa County; Schmidt, Jour. Mamm., 12: 116, 1931), and, according to an early report, in southeastern Wisconsin (Merriam, N. Amer. Fauna No. 9: 120, 1895).

In northernmost Wisconsin on July 16, 1951, the writer took two specimens of *Geomys*

bursarius from the road bank of U. S. Highway 2, four miles east of Iron River, Bayfield County. Gopher mounds were noted in abundance along the highway from Iron River to Ino. The locality from which the specimens were taken is more than one hundred miles north of Anson Township and is only fifteen miles from Lake Superior. The specimens have been given to the University of Illinois Museum of Natural History.—WAYNE H. DAVIS, *Museum of Natural History, University of Illinois, Urbana.* *Received January 29, 1954.*

NOTES ON YOUNG POCKET GOPHERS

While conducting an investigation on the pocket gopher (*Geomys breviceps brazensis* Davis) in Brazos County, Texas, during the spring and summer of 1947, six nests with litters of young were observed.

English (Jour. Mamm., 13: 122–132, 1932) describes the nest-mound, nest, and runway of this pocket gopher. He located four nests containing young but did not give a complete description of them.

The nests here observed were composed entirely of dry Bermuda grass and weighed an average of 61.5 grams as taken from the mound. There was a single exit from each nest and a tunnel from four to eight inches long and two and one-half inches in diameter that joined the nest to the underground network of tunnels. The runway system of a lactating female honeycombed an area 97 feet long and 47 feet wide. Nowhere did her runway join the runways of other gophers found in the same field.

Since the six broods observed fall into three distinct age groups only three of the broods will be described.

Brood 1.—The youngest brood, collected April 26, contained three young. It is believed this brood was not over one day old for, in addition to the presence of a fresh umbilical cord, their weights and lengths were only slightly larger than the largest embryos that had a crown-rump length of 35.9 mm. and a weight of 3.6 grams. This is a difference between embryos and nestlings of only 2.1 mm. in length and 0.5 gram in weight.

These young resemble the adult, but the cervical flexure and lumbar dorsal arch are more acute. The head is more ovoid, and the cranial region more strongly arched.

Since the measurements for the three individuals of this litter, and of the other litters discussed, are so nearly the same, those of only one animal are given: (all measurements are in millimeters) total length, 49; tail length from constriction, 7.2; hind foot, 6.5; crown-rump length, 38; head length, 14; greatest diameter of tail, 3.2; diameter of tail at constriction, 2.8; mouth opening, 3; length of claw of longest toe of manus, 1.2; weight, 4.3 grams.

The skin was loose, wrinkled, and pink. The wrinkles were of two types, large and running laterally across the body, and small and running diagonally across the body. The tail was covered with tightly stretched, colorless skin.

The body was haired with minute, grayish hairs 0.15 mm. long. The vibrissae were 0.9 mm. long. The eyes were closed and the cheek pouches were represented only by a line 4 mm. long. The external ears were small inconspicuous buds. The teeth had not erupted, and the palatine lobes of the upper lip were rudimentary.

When disturbed, the young uttered a rasping squeak and kicked their limbs with no coordination in attempting to right themselves, a position they could not maintain. They rested on their sides with their head bowed almost to the tip of the tail, which pointed ventrally and anteriorly.

Brood 2.—The brood of the second age group includes three young collected May 26. Their general appearance was similar to those in the youngest brood. The skin was loose, but not wrinkled, gray above and light pink below. The tail had lost the constriction at the base. The body was well haired. The hairs of the back were gray and 2 mm. long. The belly hairs were white and 1 mm. long. The vibrissae were 3.5 mm. long and arose from a pinkish area.

The measurements were total length, 77; tail length, 15; hind foot, 10.5 length of head, 20; crown-rump length, 53; longest claw of manus, 2; weight, 11.5 grams.

The cheek pouches were represented by a line 8 mm. long. The ears were poorly developed and the eyes were closed. Both upper and lower incisors had erupted and showed as smooth white pegs 0.4 mm. long and 0.6 mm. apart. The palatine lobes of the lips had not joined behind the incisors. This group showed but little more control over their movements than was exhibited by the younger group.

Brood 3.—The oldest brood, also containing three young, was collected May 26. They closely resembled the adults in color and form but had a greater lumbar-dorsal arch. The measurements were total length, 107; tail length, 33; hind foot, 17; crown-rump length, 68; longest claw of manus, 5; weight, 22.5 grams.

The eyes were ready to open. The ears resembled those of the adult. The cheek pouches were 10 mm. deep with a 12 mm. opening. The palatine lobes of the lips met behind the incisors. The incisors resembled those of the adult in color and form. The upper ones were distinctly bicusped, 2.5 mm. long and 1 mm. wide.

Young in this litter nibbled at soft foods but apparently were not completely weaned, for they attempted to nurse when placed with the mother. Their equilibrium was not steady and they had difficulty in moving from place to place. They rested and slept in the position used by adults.—JOHN E. WOOD, *Department of Wildlife Management, Agricultural and Mechanical College of Texas, College Station.* *Received February 28, 1954.*

THE DISTRIBUTION OF THE MARSH RABBIT IN GEORGIA

In an earlier account (Tomkins, Jour. Mamm., 16: 201–205, 1935) some life history notes on the marsh rabbit, *Sylvilagus palustris paludstris*, were recorded as observed in the delta marshes of the Savannah River. It is now possible to give a somewhat clearer account of the distribution of this water-loving lagomorph in the Coastal Plain of Georgia.

There are five rivers that empty into the ocean from inland Georgia. Beginning at the north these are the Savannah, Ogeechee, Altamaha, Satilla, and St. Marys. The Savannah and the Altamaha are silt-laden rivers, originating largely above the Fall Line and having true deltas at the mouth. The other three are Coastal Plain rivers carrying "blackwater," and each emptying into the ocean through a gorge without a true delta.

It appears that the large populations of marsh rabbits are in the brackish marshes of the Savannah and Altamaha rivers, and that it occurs in lesser numbers about the mouths of the other rivers, though there are a few here and there in swampy places up to the Fall Line.

When the salinity increases beyond a certain point, the numbers of rabbits decrease until it is doubtful if any are found in strictly salt marsh. Wilmington Island, Chatham County, is 2½ miles by water from the Savannah River, but the river water influences the north end where there is a fair marsh rabbit population. Toward the south end where the salinity is greater, the rabbits appear to be absent, in spite of the fact that the dominant marsh grass, *Spartina alterniflora* Loisel, is practically continuous around the edges of the entire island. Other similar situations could be cited.

Much of the data on which the foregoing is based comes from personal observation, but various individuals, hunters, fishermen, etc., have helped to fill in the picture, though one must be careful when evaluating this kind of information.

Mr. Frederick V. Hebard has furnished information that the species is common at Coleraine, halfway from the ocean to the Okefinokee Swamp, though I have no way of knowing how common. Mr. Isaac F. Arnow, a fine naturalist and lifelong resident of St. Marys, Camden County, told me in a conversation on December 8, 1948, that the species is found there, but not plentifully.

Some measure of the numbers to be found in optimum habitat is indicated by the results from three early morning counts made on Cockspur Island, in late June and early July, 1953. The Fort Pulaski National Monument is on Cockspur Island, and there has been no rabbit hunting since the close of the last war, and no predator control except the destruction of a few rattlesnakes. The island is between the north and south channels of the Savannah River at the entrance, and has supported a good population of marsh rabbits for many years.

On these three mornings I drove over the same bit of road, 1.3 miles long by the speedometer, and counted 27, 39, and 42 rabbits respectively. A couple of other morning counts were disturbed by traffic or bad weather and are not included. The shrubbery is thick up to the road berms in most places, and the rabbits seen were out in the open.—Ivan R. Tomkins, *1231 East 50th Street, Savannah, Georgia.* *Received November 23, 1953.*

UNUSUAL TWIN FAWNS IN DESERT MULE DEER DOE

On July 7, 1953, an adult mule deer doe, *Odocoileus hemionus eremicus*, was collected on the Kofa Game Range, Yuma County, Arizona, by Game Technician John P. Russo and Technician Homer G. Erling of the Arizona Game and Fish Commission. The collection was made as part of the desert bighorn sheep investigation being conducted under P-R Project W-55-R-3, with cooperation from the Branch of Refuges, U. S. Fish and Wildlife Service.

The normal collection of specimen samples included the gravid uterus and ovaries. On examination of the reproductive tract in the laboratory, it was found that a great variation in size existed for the twin female fetuses. The smaller fetus, in the right horn of the uterus, weighed 204.5 grams. Some of the body measurements were: total length 28.5 cm., foreleg (from olecranon process to hoof point) 8.5 cm., and the hindleg 9.5 cm. (from the tubercle of the tibia-fibula to the hoof point).

The larger fetus, in the left horn of the uterus, weighed 1956 grams and measured (in the above order) 36 cm., 12 cm., and 13 cm.

According to Armstrong's key (Am. Midl. Nat., 43: 650–666, 1950) the smaller is about 100 days old and the larger about 120 days old.

Gross examination of the ovaries indicated only one corpus luteum of pregnancy in the right ovary, and one pigmented remnant of the previous season's pregnancy in the left ovary.

Neither fetus evidenced any sign of abnormality, mummification, or resorption. A fragment of the bullet damaged the left side of the head of the smaller fetus; otherwise the specimens were in perfect condition.—D. J. Illige and Homer G. Erling, *Arizona Game and Fish Commission, Phoenix.* *Received November 16, 1954.*

FETUS IN YEARLING COW ELK, *CERVUS CANADENSIS*

A survey of the literature indicates that few cases of pregnancy have been observed in yearling cow elk. Mills (Jour. Mamm., 17: 250–253, 1936) found one of five yearlings pregnant. Kittams (Jour. Wildlife Mgt., 17: 177–184, 1953) found one pregnant of 39 observed between 1949 and 1951. He also found one of 28 two-year-old cows lactating, indicating pregnancy the previous year. Coffin and Remington (Jour. Wildlife Mgt., 17: 223) found one pregnant of seven examined.

A cow elk killed in Gallatin Canyon, Montana, November 29, 1953, was examined and found to be pregnant. The age of the elk was established as a yearling (approximately 18 months) according to the method of aging elk by teeth described by Murie (THE ELK OF NORTH AMERICA, 1951).

The fetus was in the right horn of the uterus. Its crown-rump length was 30.7 mm. Another partially resorbed fetus was present in the left horn of the uterus.—Jack K. Saunders, Jr., (*Montana State College*) *2709 First Avenue North, Great Falls, Montana.* *Received January 29, 1954.*

MOOSE, *ALCES ALCES*, BATTLES HORSE IN WATER

On a day in June, looking down from a hillside into the valley of the upper Snake River east of the Tetons in Jackson Hole, I noticed a band of horses swimming through the river to an island, green with luscious grass. A few minutes later two more heads were showing in the water, but it was apparent that they did not proceed without difficulties. In fact, they seemed to collide, and the fieldglasses revealed that one of them was a horse, the other one was a moose cow trying to hinder the horses from landing on the green island. A serious battle ensued with the horse being ducked and rapidly losing in speed and strength.

Eventually (after about 12 minutes) the horse managed to climb ashore, staggering, and tried to graze. The moose, ears folded back, turned to swim back to the other shore in swift strokes, and disappeared in the willow thicket.

It can be assumed that the horse in passing to the river banks came too close to a moose calf and that the moose cow became aroused. The surprising fact was the tenacity of the cow moose in following the horse through the water for such a distance without diminishing anger.—MARGARET ALTMANN, *Hampton Institute, Hampton, Virginia,* *Received February 10, 1954.*

CHOKECHERRY TOXIC TO AN ANTELOPE

On April 20, 1953, while studying the food habits of antelope in the Jimmy Camp Creek area, east of Colorado Springs, Colorado, the writer found an adult buck antelope (*Antilocapra americana*) that appeared to be stiff and slow in his physical movements and showed evidence of being in a weakened condition.

This animal was collected and a post-mortem examination made. The adipose tissue was abundant throughout the body cavity. There were no physical bruises, internal diseases, parasites, or malformations that could affect the animal's health. The stomach pouch contained a quantity of green, dry, food material—mainly new growth of chokecherry (*Prunus melanocarpa*).

The local veterinarian reported a similar condition in Hereford calves in this area. His explanation was that the antelope gorged himself on early spring plants. Among the plants was chokecherry. The mixing process of the digestive juices with new growth of chokecherry during the process of digestion, caused the liberation of small quantities of cyanide gas toxic to the animal.

The author believes that this condition is only a temporary ailment. It could, however, cause the animal to become easy prey for predators.—STANLEY OGILVIE, *Colorado Game and Fish Department, Woodland Park, Colorado,* *Received January 10, 1954.*

BREEDING RECORD OF JAVELINA, *TAYASSU ANGULATUS*, IN SOUTHERN ARIZONA

A group of six javelinas (*Tayassu angulatus*) was observed from 8:00 to 11:30 AM on February 16, 1954. Observation was with the aid of 9X, 50 binoculars at distances varying from 50 feet to 300 yards, at a site approximately four miles north and seven miles west of Roosevelt, Arizona. During most of the observational period the javelinas appeared to be foraging. However, at 10:15 AM, when about 100 yards from the observer, one adult javelina mounted another and engaged in copulatory motions for approximately 50 seconds; the pair then separated and moved out of sight. Others in the vicinity continued feeding, and showed no reaction to the breeding activity.

This is the only actual breeding of javelina noted during 16 months of continuous field work in this area, although 41 encounters with groups of javelinas were recorded, totalling approximately 268 individuals. The number of non-repeat sight records is unknown. This act, if it is typical of the javelina, is of interest in comparison with the protracted breeding act of the domestic hog (*Sus scrofa*).

The following notes are offered regarding the time of year when javelina young may be born in Arizona.

Tiny, brown-colored young javelinas, assumed to be less than three weeks old, were seen in the Roosevelt vicinity on November 27, 1952, on May 6, 1953, on September 15, 1953, and December 7, 1953.

A female javelina bearing two well-developed fetuses was killed during the hunting season, on February 14, 1954. The fetuses were left at the Phoenix office of the Arizona Game and Fish Commission by the hunter, who did not leave a record of the location of the kill.—CLAY Y. MCCULLOCH, JR., *P.O. Box 1114, Roosevelt, Arizona.* *Received March 3, 1954.*

A COMMENSAL NEMATODE IN THE AFRICAN BUSH PIG

An adult male bush pig *Potamochoerus porcus nyassae* was shot at Solwezi, Northern Rhodesia, on November 18, 1952. While this specimen was being skinned, the presence of a buccal pouch was noticed. This pouch consisted of a diverticulum lying parallel and adjacent to the labial surface of the maxilla, which opened anteriorly into the buccal cavity by an elongated vertical aperture just posterior to the alveolus of the upper canine tooth. When opened, this pouch was found to contain a mass of wood and bark debris in which were numerous specimens of nematode worms, *Rhabditis* sp. The pouch on the left side of the head was more heavily infected than that on the right.

This buccal pouch may function in a manner similar to the diastema of rodents, in preventing debris from being swallowed when the pig is rooting, and would provide an adequate ecological niche for free living nematodes initially picked up from the soil. No lesions were observed in the pouch, and it would appear that that the nematodes fed on the debris that it contained. This fact suggests that a commensal association exists between the two organisms.

The writer wishes to thank Mr. S. Prudhoe of the British Museum of Natural History for identifying the nematodes. The macerated condition of the specimens obviated a more accurate conclusion.—Basil J. G. Marlow, *4 High Street, Farningham, Dartford, Kent, England.* *Received November 24, 1953.*

REVIEWS

Palmer, Ralph S. The Mammal Guide. Doubleday and Company, Inc., Garden City, New York. 384 pp., 40 colored pls., 37 line drawings, 145 maps, 2 end papers. Price, $4.95.

For nearly a quarter of a century the field book of north american mammals by H. E. Anthony was the only available handbook for the amateur or non-technical mammalogist. Dr. Anthony's book was a great contribution and no doubt was instrumental in interesting many students, both young and old, in mammals. Contained within this well illustrated work are the common and scientific names of most of the mammalian species and subspecies recognized from north of the Rio Grande in Gerrit S. Miller's list of north american recent mammals 1923, their descriptions and ranges, as well as brief accounts pertaining to the natural history of the various groups.

With the greatly increased interest in all phases of science, mammalogy included, that has come about in the past several decades and the wealth of new data that has accumulated it is inevitable that a book such as Dr. Anthony's must ultimately go out of date. Intensive collecting has given us a more complete picture of the ranges of most species. Field studies have greatly added to our knowledge of the life histories of mammals, and taxonomists have not only named hundreds of new geographical races but have combined many species previously considered as distinct. To revise and bring up to date the field book of north american mammals, using the original format which included all subspecies, would have resulted in a volume too bulky for practical field use. Furthermore, it is generally conceded now that the problem of subspecies belongs to the museum specialist and has no place in a field guide.

The constantly growing need for a new mammal handbook was partly filled by the appearance in 1952 of a field guide to the mammals written by William H. Burt and illustrated by Richard P. Grossenheider. Dr. Burt's book contains descriptions of each of the three hundred and seventy-three species of mammals occurring north of the Mexican boundary. Excellent maps show the ranges of all of these forms, excepting those inhabiting the oceans, and in most instances a sentence or two is devoted to the habitat preferred by each species.

the mammal guide by Dr. Ralph S. Palmer combines some of the qualities of the two field guides previously mentioned. It contains brief descriptions, accompanied by distributional maps delimiting ranges, for each of the mammalian species occurring north of Mexico.

In addition to serving as a guide for identification it enables the reader to learn a great deal about our various North American mammals. For most species separate paragraphs are devoted to habitat, reproduction, habits, and economic status. Certain groups represented by large numbers of closely related species, as for example ground squirrels, pocket mice, or voles, are considered collectively as far as their natural history is concerned. This eliminates a great deal of repetition which otherwise would necessarily occur. The telegraphic style plus the use of numerous abbreviations in many places do not make for easy reading but doubtless were necessary in order to keep the volume within reasonable size.

For the most part the vernacular names agree with those used by Burt but there are a number of differences. This reviewer is not implying that Burt's selection was the best but he is aware of the confusion that will arise in the mind of the amateur when the same species is referred to as a Tree Phenacomys in one book (Burt's) and a Red Spruce Mouse in another book (Palmer's) published two years later. The fault here lies not so much with the authors as with the general apathy accorded vernacular names by American mammalogists and the lack of any standardization in this field which is so important to the beginner.

Certain inconsistencies are evident in some of the distribution maps, especially with respect to species whose ranges have been greatly curtailed as a result of human settlement in North America. The present restricted range of the grizzly bear, the gray wolf, and the bison are shown on the respective maps for these species, while for other species whose ranges have also undergone marked restriction, like the sea otter and pronghorn, their ranges are shown essentially as they were at the time of the arrival of the white man. One is also inclined to suggest that distributional maps should be designed so as to give some indication of relative abundance. The beginner, on examining the maps of the free-tailed bats on page 76, might conclude that the big free-tailed bat (*Tadarida molassa*) is more common in western North America than the Mexican free-tailed bat (*Tadarida mexicana*). Actually, only fourteen specimens of the former have been recorded north of Mexico (Cockrum, Jour. Mamm., 33:492, 1952), while the Mexican free-tailed bat is extremely common throughout its range. The map for the spotted bat (*Euderma maculata*) is equally misleading in that there are only twelve records for this species (Benson, Jour. Mamm., 35:117, 1954). although this is implied in the text. In such instances it would appear that dots representing localities of capture would present a far more accurate picture.

Dr. Palmer's book contains two hundred and fifty figures in color, illustrating one hundred and eighty-two species as well as thirty-seven line drawings including the tracks of a number of mammals. All the illustrations were prepared by the author. The color rendition of many of the plates, in the reviewer's copy at least, is somewhat less than desired and there is considerable question in his mind as to the value of a number of the pictures. It is unlikely that either the amateur or the expert would find illustrations of the various deer mice, harvest mice, or chipmunks any aid in specific recognition.

These are minor criticisms that come to the mind of the reviewer. In all it can be said that THE MAMMAL GUIDE is notably free from errors and the few that are present in the first printing have already been corrected. This book will prove extremely useful both to beginners and to experienced mammalogists for many years to come. The author merits high commendation for consolidating a vast number of facts into one concise work and the publisher, Doubleday and Company, deserves praise for producing an extremely attractive volume of a size that is highly satisfactory for both the desk and use in the field.—ROBERT T. ORR, *California Academy of Sciences, San Francisco, and the University of San Francisco, California.*

Trippensee, R. E. WILDLIFE MANAGEMENT. FURBEARERS, WATERFOWL AND FISH. VOL. II. McGraw Hill, New York. xii + 572 pp., illus., 1953. Price, $7.50.

In this second volume on wildlife management, Dr. Trippensee and his co-workers made an attempt to describe a wide range of subjects, including water conservation, marsh management, and the life histories, ecology and management of fur bearers, waterfowl and fish.

Although certain sections of the book, such as those on water conservation and marsh management, are well written and clearly understandable, other parts are poorly organized and edited, and often leave an incoherent picture in the mind of the reader. The section on fur bearers in particular leaves much to be desired. It is not clear to the reviewer why a major part of the book was used for a discussion of fish, especially since several excellent recent books are available on this subject.

Trippensee's courage in undertaking this exhaustive job should be admired, but it is unfortunate that his book expresses a generally existing malady of the wildlife field, namely overemphasis of details and lack of interpretation of facts. The principles and philosophy of wildlife management and its place in multiple land use are not adequately discussed.

More careful editing could have resulted in the omission of meaningless generalizations, and repetitious or erroneous statements.

In the chapter on beavers it is stated on page 57 that: "beavers seem to be gaining slightly," while actually this species was rapidly on the increase. In the next sentence the author remarks that as of 1952 muskrats have been on the decline for a number of years, which must be an error in printing. At least on page 59 it is further stated that from 1945 the 'rat showed its greatest decline. On page 72 Trippensee mentions that no reason is given by Benson, in his paper on the sex ratio and breeding of the beaver in Michigan, for the fact that more males than females occur among the two-year-olds and adults. Benson states, however, that his findings are probably not significant because of the small sample collected. On page 73 it is remarked that bark is eaten from the chips, which is repeated on page 76. The management of beaver in Canada, which in several respects is more advanced that in the United States, is not discussed.

Although the movements of coyotes are discussed under a separate heading, no mention is made of W. B. Robinson's excellent study published in 1951.

In the discussion about the fisher it is said that the fur of the fisher is silky. This is only true for females. The remark that the fur of the fisher is almost a novelty in the fur trade does not hold true for Canada.

The reviewer does not agree with the statement made on page 173 that "martens have reached a low point in numbers on the entire North American continent." There are many places in Canada and some in the United States where populations are up to the carrying capacity level. On page 174 the author quotes erroneously from Dominion Fur Statistics: Canada produced 14,319 pelts of marten during the year 1949–1950 (not 265,680) and 15,051 pelts in 1947–1948. The 1949–1950 harvest is about equal to and not about half the number harvested during the season 1947–1948 as mentioned in the book. On the same page no reference is made under "management" to a paper on the overflow and dispersal of marten and fisher from wildlife refuges (Jour. Wildlife Mgt., 15: 164–175, 1951). No information is given about the status of the wolverine in Canada.

Although most of the maps of the breeding and wintering ranges of waterfowl are correct, those on the ring-necked duck, bufflehead and American merganser could stand improvement.

A further discussion of similar discrepancies in other chapters seems to be pointless. Moreover, the reviewer does not feel competent to criticize the fish section. However, the reader should be forewarned by the above discussion, especially when the volume is used as a text.

It would be unfair to the author and his cooperators not to acknowledge that the book is a useful addition to the library of a wildlife manager. Many facts are presented that are not easily found in the literature. The volume is well illustrated.—A. DE VOS, *Ontario Agricultural College, Guelph, Ontario.*

Couturier, Marcel A. J. L'OURS BRUN, URSUS ARCTOS L. Marcel Couturier, 45, Rue Thiers, Grenoble, Isére, France. xi + 905 pp., 49 figs., 82 pls., 1954. Price (in one volume), 8,300 francs (about $24.00); (in two volumes, special paper), 15,300 francs.

The brown bears, including the grizzlies, have long been in need of attention from mam-

malogists. In this massive work by Dr. Couturier they receive an ample share of it. Fifteen years in preparation, the book covers almost every conceivable aspect of the biology of these bears.

One of the most far-reaching and outstanding conclusions of the work is that all the brown bears of the world constitute one species, *Ursus arctos* L. In a chapter entitled "Le problème de l'espèce chez les ours bruns" the author reviews the taxonomic history and evidence in detail before coming to this conclusion. Systematic literature of the last century on the brown bear is reviewed briefly but that of this century is covered in greater detail. Prominent in the discussion is the well known work of Merriam who listed 71 species and 15 subspecies of grizzly bears and brown bears in one publication. After carefully reviewing Merriam's work. Dr. Couturier presents his reasons for dismissing all these and other species of grizzly and brown bears as synonyms of *Ursus arctos*. It is possible here to mention only briefly some of his reasons for doing this. He points first to the extraordinary morphological plasticity of the brown bear and demonstrates this most convincingly for the brown bear of the Pyrenees stating that, "Je pense que Merriam aurait créé 17 espèces avec les 17 tetes osseuses d'Ours des Pyrénées de ma collection, car toutes sont différentes." Pointing to similar plasticity in the brown bear elsewhere (as in Alaska), the author states that much of this variability is explainable on ecological causes. He points also to the strong tendency toward variability in small populations as compared to large populations, and to the Sewall Wright "effect" working in such populations. Dr. Couturier proposes to abandon all attempts to indicate subspecies within *Ursus arctos* and merely to refer to local groups as "populations." In this way he hopes to avoid assigning false genetic relationships to relatively small, variable populations of brown bears.

Some of this may come as a shock to some American taxonomists. Others may see considerable logic in the author's thesis. For the taxonomic treatment previously accorded these bears by some Americans, Dr. Couturier uses the expression "Pulvérise abusivement le genre . . ." The translation of this is somewhat stronger than mere "splitting"! It is also observed that "Le naturaliste de Washington [Merriam] a malheureusement fait école et ses idees sur la spéciation ont été adoptées, à peine modifiées, par le nombreux mammalogistes américains."

The book has three main parts. Part I is entitled "Histoire Naturelle"; Part II, "Ethologie"; and Part III, "Chasse." Within these sections is contained a vast amount of information on the brown bear, and it is possible here to comment on only a small part of it. The printed table of contents occupies almost eighteen pages alone.

As an example of the thorough treatment of the subject throughout one may observe that in a chapter on weights, the topic is treated in detail geographically and according to age, sex, season, and environment. Pelage, in another chapter is described in great detail microscopically as well as macroscopically. Details of anatomy and physiology are presented, with the individual bones and teeth beautifully illustrated by halftones, in addition to the entire skeletons and separate skulls.

At this point one may comment that the general quality and clarity of the halftone reproductions put many American publications to shame. Presumably a very fine halftone screen was used in reproduction. In any case the details visible in the skeletal plates are a pleasure to see.

There are radiographs of the skeletons of term fetuses, and the pattern of tooth succession is shown by radiographs and matching line drawings. There are notes on caries, wear, and anomalies of the teeth, in addition to complete descriptions of the normal dentition. The taxonomic section has already been mentioned. Parasites and diseases are not neglected, nor are geographic distribution (65 pp.), or fossil bears (50 pp.). The impact of the brown bear on history, art, literature, and science is discussed at length, including its relation to such diverse subjects as philately, heraldry, and numismatics.

In Part II, all aspects of the ecology of the brown bear are discussed in detail, but space does not permit a discussion here. It must suffice to say that the subject is covered thoroughly. Some of the subjects treated are environment, territory, density, temperament,

physique, senses, motion and locomotion, food, social life, activity, winter sleep, relations to other animals, movements, enemies, captives, and injurious habits.

Part III on hunting reveals that the author is himself an ardent "chasseur d'ours." The number of pages devoted to this section (190) might seem excessive, but examination shows that, with characteristic thoroughness, the author discusses hunting from a very broad viewpoint. Included are details on bear reserves and national parks in all countries where these bears find refuge. Hunting regulations of all countries are presented and discussed, and regulations proposed for France.

There is also a chapter here on cults of the bear, the relation of the bear to religions, totem poles, and mythology. The final chapter is on the future of the species. On this point Dr. Couturier is justifiably pessimistic.

The book has an extensive bibliography of about 70 pages and contains an alphabetical index of authors and persons mentioned, an index of geographic names, and one of Latin names.

L'OURS BRUN will stand for a long time to come as a definitive work on the brown bear. It will serve as an almost inexhaustible summary of what is known about these magnificent mammals, and it should most certainly serve to stimulate further research before these great animals are retired to a few scattered preserves or to the dusty shelves of museums. Perhaps it will help to delay the arrival of this sad day.—W. ROBERT EADIE.

NOTE

The American distributor for the book reviewed in the November, 1954, issue of the *Journal of Mammalogy*, "Primates: Comparative Anatomy and Taxonomy. Volume I: Strepsirhini" by W. C. Osman Hill, is Interscience Publishers, Inc., 250 Fifth Avenue, New York 1, N. Y. The price of the book is $15.75.

RECENT LITERATURE

(Conducted by David H. Johnson, Claude W. Hibbard, Charles P. Lyman, Richard H. Manville, and Henry W. Setzer)

[Reprints of this section may be purchased from the Corresponding Secretary]

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COMMENTS AND NEWS

ANNUAL MEETING

The thirty-fifth annual meeting of the American Society of Mammalogists will be held at the University of Southern California at Los Angeles, June 12–16, 1955.

The Local Committee consists of William V. Mayer (Chairman), Robert M. Chew, Edward T. Roche, Kenneth Stager, George H. Pournelle, and Henry Childs.

Rooms and meals will be available on the Campus.

Two dormitories will be allotted. One will be for males, the David X. Marks Hall, 3560 South Hoover Blvd. The second dormitory will be for women and family groups, the Town and Gown Hall, 666 West 36th Street. The cost will be $2.25 per person per night. Reservations should be made well in advance by writing to the Head Resident at the address given for each hall. No deposit will be required.

CALL FOR PAPERS FOR ANNUAL MEETING

Now is the time to make plans for presenting a paper at the 35th Annual Meeting at Los Angeles. By submitting titles early you will help the Corresponding Secretary to arrarrange an interesting program.

He will need the title of the paper, time required for presentation (limited), equipment needed, and a brief summary if possible.

Send this information to Dr. George C. Rinker, Department of Anatomy, University of Michigan, Ann Arbor, Michigan.

HONORARIA FOR YOUNG MAMMALOGISTS

Your attention is called to the availability of two Honoraria (of $100.00 each) for Young Mammalogists. These may be awarded for papers submitted by young mammalogists who have not yet attained the Ph.D. degree. Their purpose is to stimulate research and to help defray the costs of attending and presenting a paper at the Annual Meeting.

Papers submitted in competition for these awards for 1955 must be in the hands of the Committee by April 1, 1955. All such papers submitted will be reviewed by the Committee after that date. Successful applicants will be notified in ample time to make plans for attending the Annual Meeting.

Send manuscripts to the Chairman of the Committee, W. Robert Eadie, Fernow Hall, Cornell University, Ithaca, New York.

CORRECTION

Cahalane, Victor H. 1954. The black-footed ferret. Jour. Mamm., 35(3): 418–424.

"The first word on page 419 should be *Colorado* rather than *Nebraska*. The error goes. . . back to my manuscript, ..."—VICTOR H. CAHALANE.

ZOOLOGICAL NOMENCLATURE

Notice of proposed use of the Plenary Powers in certain cases for the avoidance of confusion and the validation of current nomenclatorial practice (A. (n.s.) 20).

Notice is hereby given that the possible use by the International Commission on Zoological Nomenclature of its Plenary Powers is involved in applications relating to the undermentioned name[s] included in Parts 10 [and 11] of the *Bulletin of Zoological Nomenclature*, each of which Parts will be published on 30th December, 1954:

(1) *Application[s] in Part 10 of Volume 9 [Only one on Mammalia].*

Dama Frisch, 1775 (Class Mammalia), proposed validation of, for use for the name for the Fallow Deer of Europe (pp. 293–300) (Z.N. (S.) 96).

(2) The present Notice is given in pursuance of decisions taken, on the recommendation of the International Commission on Zoological Nomenclature, by the Thirteenth International Congress of Zoology, Paris, July, 1948 (see *Bull. Zool. Nomencl.* 4:51–56, 57–59; *ibid.* 5:5–13, 131).

(3) Any specialist who may desire to comment on [any of] the foregoing application[s] is invited to do so in writing to the Secretary to the International Commission (Address: 28 Park Village East, Regent's Park, London, N.W.1., England) as soon as possible. Every such comment should be clearly marked with the Commission's File Number as given in the present Notice.

(4) If received in sufficient time before the commencement by the International Commission of voting on the applications in question, comments received in response to the present Notice will be published in the *Bulletin of Zoological Nomenclature*; comments received too late to be so published will be brought to the attention of the International Commission at the time of the commencement of voting on the application in question.

(5) Under the decision by the International Congress of Zoology specified in paragraph (2) above, the period within which comments on the application[s] covered by the present Notice are receivable is a period of six calendar months calculated from the date of publication of the relevant Part of the *Bulletin of Zoological Nomenclature*. The two Parts now in question will be published on 30th December, 1954. In consequence, any comments on the applications published in these two Parts should reach the Secretariat of the International Commission at latest by 30th June, 1955.—Francis Hemming, *Secretary to the International Commission on Zoological Nomenclature.*

DATE OF ISSUE OF PREVIOUS NUMBER

Journal of Mammalogy, Vol. 35, No. 4 was mailed November 29, 1954

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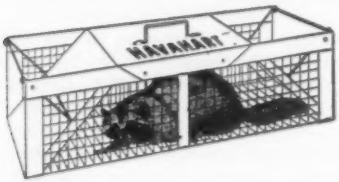

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Contents—*Continued from cover 4*

General Notes—*Continued*

The Occurrence of *Tamias striatus* in Georgia.....*James C. Knepton, Jr.* 136
Taxonomic Status of Ground Squirrels, *Citellus lateralis* (Say), from Northeastern Utah and Northwestern Colorado
Stephen D. Durrant and Richard M. Hansen 136
Muskrat Remains from a Prehistoric Indian Site in Jackson County, Florida.....*Wilfred T. Neill and Ripley P. Bullen* 138
Notes on the Florida Pine Mouse, *Pitymys parvulus* Howell
Wilfred T. Neill and James M. Boyles 138
The Effect of Cold Starvation upon Carbohydrate Reserves in *Peromyscus maniculatus*.....*Paul S. Eskridge and Robert H. Udall* 139
Notes on the Carolinian Jumping Mouse in Connecticut
Sydney S. Walton, Jr. 140
Techniques of Sexing Beaver, *Castor canadensis*.....*Dale J. Osborn* 141
Northern Extension of Range of Pocket Gopher East of the Mississippi
Wayne H. Davis 142
Notes on Young Pocket Gophers.....*John E. Wood* 143
The Distribution of the Marsh Rabbit in Georgia.....*Ivan R. Tomkins* 144
Unusual Twin Fawns in Desert Mule Deer Doe
D. J. Illige and Homer G. Erling 145
Fetus in Yearling Cow Elk, *Cervus canadensis*.....*Jack K. Saunders, Jr.* 145
Moose, *Alces alces*, Battles Horse in Water.....*Margaret Altmann* 145
Chokeberry Toxic to Antelope.....*Stanley Ogilvie* 146
Breeding Record of Javelina, *Tayassu angulatus*, in Southern Arizona
Clay Y. McCulloch, Jr. 146
A Commensal Nematode in the African Bush Pig.....*Basil J. G. Marlow* 147

Reviews..... 147
Recent Literature..... 151
Comments and News..... 160

SUGGESTIONS TO AUTHORS

The *Journal of Mammalogy* publishes original papers with significant new content on any phase of the science of mammalogy. While authors need not necessarily be members of the society, it is suggested that individuals publishing serious papers in this field should consider carefully the desirability of associating themselves with the American Society of Mammalogists.

Papers are generally published in order of receipt with some exceptions at the discretion of the editor. Papers over twenty printed pages in length are rarely published because of costs and limitations of space. When partly subsidized, such papers may occasionally be published at the discretion of the editorial committee.

Photographic illustrations (half-tones) and tabular matter are strictly limited because of high costs of printing. Half-tones for decorative purposes, or interest only, will not be published; they should illustrate some point or fact, best shown in this way, and essential to the exposition of the paper. Tabular matter should contain data not repeated in text.

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CONTENTS

Page

Speciation and Dispersal of the Southern Bog Lemming, *Synaptomys cooperi* (Baird) ..... *Ralph M. Wetzel* 1

Population Studies on Some Small Forest Mammals in Eastern Canada ..... *F. F. Morris* 27

An Unusual Abundance of Short-tailed Shrews, *Blarina brevicauda* ..... *C. David Fowle and R. Y. Edwards* 36

Home Range of *Peromyscus maniculatus rufinus* in a Ponderosa Pine Community ..... *Owen Williams* 42

A Technique for Investigating the Distance Parameter of Home Range ..... *John B. Calhoun* 45

Observations on the Life History of the Northern Pine Mouse ..... *Allen H. Benton* 52

Biology of the Indian Mongoose in Puerto Rico ..... *David Pimentel* 62

Behavior Patterns in a Laboratory Colony of Prairie Dogs, *Cynomys ludovicianus* ..... *Adam Anthony* 69

The Brain of the Chimpanzee at the Time of Birth (Myelogenesis) ..... *Walther Riese* 78

Pelage of the Porcupine, *Erethizon dorsatum dorsatum* ..... *Donald S. Po-Chedley and Albert R. Shadle* 84

Additional Data on the Bacula of North American Bats ..... *Philip H. Krutzsch and Terry A. Vaughan* 96

Notes on Mammals of Perry County, Ohio ..... *Brice Metzger* 101

The Status of the Species of the *Brasiliensis* Group of the Genus *Tadarida* ..... *Albert Schwartz* 106

A New Subspecies of *Chilonycteris* from the West Indies and a Discussion of the Mammals of La Gonave ..... *Karl F. Koopman* 109

Description of a New Race of Woodrat from Key Largo, Florida ..... *H. B. Sherman* 113

General Notes 120

Banding Mexican Free-tailed Bats ..... *R. B. Eads, J. S. Wiseman, and G. C. Menzies* 120

Some Mammal Locality Records from Iowa ..... *Lowell S. Miller* 121

Distributional Notes on Small Mammals in Northern Manitoba, Canada ..... *W. B. Quay* 123

Another Record of the Least Shrew from Northeastern Colorado ..... *Richard G. Beidleman and Jack D. Remington* 123

Notes on Irisq Insectivora and Chiroptera ..... *Neal A. Weber* 123

Additional Distributional Records of Bats in Utah ..... *Philip H. Krutzsch and Caroline A. Heppenstall* 126

New Records for Bats in Oklahoma ..... *Bryan P. Glass* 128

Nomenclature of Some Tertiary Chiroptera ..... *Charles O. Handley, Jr.* 128

Myotis subulatus leibii Found in Unusual Situations ..... *Wayne H. Davis* 130

A Record of *Lasiurus* and of *Vampyrops* from Paraguay ..... *H. B. Sherman* 130

Observations on Hoary Bats in a Storm ..... *Harry H. Gochring* 130

A Case of Polydactyly in the Colugo, *Cynocephalus* ..... *C. C. D. Shute and A. d'A. Bellairs* 131

A Recent Record of Lynx in Michigan ..... *Albert W. Erickson* 132

False Heat in the Yearling Coyote, *Canis latrans* ..... *Robert K. Enders* 133

A Recent Record of the Marten in Minnesota ..... *Milton H. Stenlund* 133

Blood Picture of the American Black Bear, *Ursus americanus* ..... *Arthur Smith, Howard Bowman, and Roger Pearson* 134

Blood Volumes in the Golden Hamster ..... *Arthur Smith and Howard Bowman* 135

Hairless Squirrels ..... *Roger M. Latham* 136

Continued on page 168